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CONTENTS.

PAGE

Fifty-ninth General Meeting :—

The Elimination of Oil-Field Waste, by A. BEEBY THOMPSON, O.B.E., M.I.Mech.E., M.Inst.M.M., F.G.S. 1

Discussion : THE PRESIDENT, Mr. HUDSON HOBDEN, Prof. MADGWICK, Messrs. WM. IVEY, A. FRANK DABELL, and ALBERT MILLAR 32

Contributions from Messrs. MAY, ASHWORTH, IBBETT, KEWLEY and McMULLEN 41

Reply by Mr. BEEBY THOMPSON 47

Sixtieth General Meeting :—

Better Production Methods, by A. FRANK DABELL, M.I.Mech.E. 50

Discussion : THE PRESIDENT, Dr. ORMANDY, Mr. BARRINGER, Mr. ASHMEAD-BARTLETT, Dr. WADE, Messrs. DABELL, MCQUEEN, IBBETT, ANFILOGOFF, KEWLEY, PENNY, PITT, and EVANS 55

Reply by Mr. A. FRANK DABELL 63

Contributions from Messrs. MAY and R. S. WARD .. 65

Insulating Oils-Colour and Sludging Characteristics, by E. B. WEDMORE, M.I.E.E. 67

Colloid Chemistry of Petroleum, by A. E. DUNSTAN, D.Sc., F.I.C., F.C.S. 73

The Colloidal State of Matter in Its Relation to the Asphalt Industry, by CLIFFORD RICHARDSON, M.Am.Soc.C.E., F.C.S. 79

Current Bibliography, compiled by W. J. WILSON, A.C.G.I., A.I.C. 83

Abstracts, compiled by F. G. P. REMFRY, B.A., D.Sc., A.I.C. 102

Sixty-first Meeting :—

An Investigation into the Physico-Chemical Significance of Flashpoint Temperatures, by W. R. ORMANDY, D.Sc., F.I.C., F.C.S., and E. C. CRAVEN 145

Discussion : THE PRESIDENT, Mr. CRAVEN, Mr. MOORE, Dr. ORMANDY, Dr. LESSING, Dr. THOLE, and Mr. E. A. EVANS 173

Reply by Dr. W. R. ORMANDY 178

The Systems Ethyl, Alcohol—Water-Paraffins from +30° C. to —30° C., by W. R. ORMANDY, D.Sc., F.I.C., F.C.S., and E. C. CRAVEN 181

CONTENTS.

PAGE

Sixty-second Meeting :—

The Significance of the Interpretation of the Chemical Analyses of Seepages, by J. E. HACKFORD, B.Sc., F.I.C. 193

Discussion : THE PRESIDENT, Sir T. HOLLAND, Dr. LESSING, Dr. J. A. L. HENDERSON, Dr. ORMANDY, Messrs. PITT and REDGROVE 206

Reply by Mr. J. E. HACKFORD 211

Note on Solubility of Benzene in Weak Alcohol, by W. R. ORMANDY, D.Sc., F.I.C., F.C.S., and E. C. CRAVEN .. 213

A Method for the Determination of the Vapour Pressure of Hydrocarbon Fuels, and the Estimation of Dissolved Air, by H. T. TIZARD and A. G. MARSHALL 217

When Oil is "Good"? by William F. PARISH 224

Current Bibliography, compiled by W. J. WILSON, A.C.G.I., A.I.C. 230

Abstracts, compiled by S. BOWMAN, A.I.C. 260

Annual Report of the Council, 1921 269

Fourth Annual Dinner, 1922 276

Ninth Annual General Meeting 292

Presidential Address, Prof. J. S. S. BRAME, F.I.C., F.C.S. .. 300

Sixty-third Meeting :—

Galicia and its Petroleum Industry, by ALBERT MILLAR, A.M.I.Mech.E. 312

Discussion : Sir T. H. HOLLAND, Mr. G. W. HALSE, Mr. C. DABELL, Prof. MADGWICK, Dr. J. A. L. HENDERSON, Mr. F. G. RAPPOPORT, and Mr. E. A. EVANS 340

Reply by Mr. A. MILLAR 344

Sixty-fourth Meeting :—

Kukkersite, the Oilshale of Esthonia, by E. H. CUNNINGHAM CRAIG, B.A., F.R.S.E., F.G.S. 349

Discussion : The PRESIDENT, Prof. WATTS, Dr. PERKIN, Mr. S. HUTCHINS, Mr. H. NIELSON, Mr. P. REUSS, Mr. G. PITT, Mr. EVANS, and MR. G. HOWELL .. 359

Reply by Mr. E. H. C. CRAIG 369

Written Contributions from Mr. A. B. THOMPSON, Prof. MADGWICK, and Mr. J. ROMANES 371

Petrols for Road Vehicles and Aircraft, by OLIVER THORNYCROFT, O.B.E., B.A. 376

Reviews 399

Current Bibliography, compiled by W. J. WILSON, A.C.G.I., A.I.C. 401

CONTENTS.

PAGE

American Chemical Society. Abstracts of Papers 431

Abstracts, compiled by S. Bowman, A.I.C., H. Moore, M.Sc., A.I.C., F.C.S., and F.G.P. Remfry, B.A., D.Sc., A.I.C. .. 434

The Shale Oil Industry of Scotland, by Edwin M. Bailey .. 465

Note on the Effect of Small Quantities of Volatile Impurities on the Flash Point of Kerosene, by E. C. Craven and B. G. Banks 490

Reviews 500

Current Bibliography, compiled by W. J. Wilson, A.C.G.I., A.I.C. 505

American Chemical Society. Abstracts of Papers 537

Abstracts, compiled by H. Moore, M.Sc., A.I.C., F.C.S., F. G. P. Remfry, B.A., D.Sc., A.I.C., and T. A. Smith, B.Sc., F.I.C. 545

Sixty-fifth Meeting :—

The Standardisation of the Testing of Petroleum and its Products, by A. E. Dunstan, D.Sc., F.I.C., F.C.S. .. 579

Discussion : The President, Mr. A. Duckham, Mr. C. Le Maistre, Mr. Anfilogoff, Mr. A. Philip, Mr. G. Pitt, Mr. E. H. C. Craig, Dr. Blackler, Sir F. Black, Mr. A. F. Gressler 601

Reply by Dr. A. E. Dunstan 613

Contributions from Mr. A. MacDougall, Mr. E. C. Craven 615

Sixty-sixth Meeting :—

The Galician-Canadian System of Pole Tool Drilling, by Albert Millar, A.M.I.Mech.E. 617

Discussion : The President, Mr. A. F. Dabell, Mr. Calder, Mr. F. A. Heaton, Dr. W. Hope Henderson, Mr. C. B. McKeever, Mr. C. Dabell, Mr. F. M. Penny 655

Reply by Mr. Albert Millar 662

Contributions from Mr. Hookham, Mr. C. Dabell .. 664

Reply by Mr. Albert Millar 664

Polish and German Bibliography of the Galician Petroleum Industry, 1875-1922 666

Review 688

Current Bibliography, compiled by W. J. Wilson, A.C.G.I., A.I.C. 690

Abstracts, compiled by Paul Dvorkowitz, Ph.D., H. Moore, M.Sc., A.I.C., F.C.S., F. G. P. Remfry, B.A., D.Sc., A.I.C., and T. A. Smith, B.Sc., F.I.C. 715

PAGE

431 Sixtieth General Meeting:—

434 Better Production Methods, by A. Frank Dabell, M.I.Mech.E. 50

465 *Discussion:* The President, Dr. Ormandy, Mr. Barringer, Mr. Ashmead-Bartlett, Dr. Wade, Messrs. Dabell, McQueen, Ibbett, Anfilogoff, J. Kewley, Penny, Gordon Pitt, and Evans 55

490 *Reply by* Mr. A. Frank Dabell 63

500 *Contributions from* Messrs. May and R. S. Ward 65

505 Insulating Oils—Colour and Sludging Characteristics, by E. B. Wedmore, M.I.E.E. 67

537 Colloid Chemistry of Petroleum, by Dr. A. E. Dunstan .. 73

545 The Colloidal State of Matter in Its Relation to the Asphalt Industry, by Clifford Richardson, M.Am.Soc.C.E., F.C.S. (Consulting Engineer, New York) 79

579 Current Bibliography, compiled by W. J. Wilson, A.G.G.I., A.I.C. 83

601 Abstracts, compiled by F. G. P. Remfry, B.A., D.Sc., A.I.C. .. 102

613

615

617

655

662

664

664

666

688

690

715

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Members of all classes are entitled to receive these publications free: for additional copies of the Journal they will be charged at the price of seven shillings and sixpence per part, and of the brochures at the prices stated on the wrappers, varying in proportion to bulk.

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Communications upon papers read at meetings, notices of personal movements, or other matter for which publication is desired in the next issue of the Journal, should be in the hands of the Editor on or before the last day of December, March, June or September as the case may be. Subsequent delivery may be too late for insertion.

The Council desire to draw the attention of authors to the serious increase in the cost of production. Papers, both for the Journal and for communication to the Institution, should be as concise and condensed as possible.

Communications. The Council invite members to submit papers for the forthcoming session. Communications to the Institution will, subject to the approval of the Publication Committee, be published in the Journal.

Appointments Register. A Register will be kept at the Offices of the Institution for the convenience of firms requiring the services of members and for members requiring appointments, but on the distinct understanding that the Institution accepts no responsibility and gives no guarantee.

Library. The Institution's Library at No. 5 John Street, Adelphi, may be consulted between 11 and 4 daily. Extensive additions are being made to the current and standard literature on Petroleum.

Additions since publication of last Journal.

From Department of Interior, U.S. Geological Survey :—

Report. Antimony in 1919. By Frank C. Schrader.

Report. Cadmium in 1920. By C. E. Siebenthal and A. Stoll.

Mines Report. Silver, Copper, Lead, and Zinc in the Central States in 1919. By J. P. Dunlop.

Water-Supply, Paper No. 468. Records of Water-Levels in Wells in Southern California. By F. C. Ebert.

Water Supply, Paper No. 481. Pacific Slope Basins in California. By Nathan C. Grover, H. D. McGlashan, and F. F. Henshaw.

Bulletin No. 721. Geology and Petroleum Resources of the North-Western Kern County, California. By Walter A. English.

Bulletin No. 726. The New Salem Lignite Field, Morton County, North Dakota. By Eugene T. Hancock.

From Mines Branch (Canada) :—

The Preparation, Transportation, and Combustion of Powdered Coal. By John Blizard.

Bulletin No. 33. Gas-Producer Trials with Alberta Coals. By John Blizard and E. S. Malloch.

From the Canadian Government Trade Commissioner :—

Oil and Gas in Alberta.

From Messrs. Charles Griffin and Co., Ltd. :—

A Treatise on Petroleum. By Sir Boverton Redwood, Bart. Fourth Edition.

From H.M. Stationery Office :—

Fuel for Motor Transport. Second Memorandum by the Fuel Research Board, Department of Scientific and Industrial Research.

The attention of members is drawn to the new supplement of the Journal which deals with current Petroleum literature. To make this section of the maximum usefulness it is necessary that there should be full co-operation between chemists, engineers and geologists, and that matter which has inadvertently escaped notice shall be immediately sent in to the Editor. The Institution has been indebted to Mr. Andrew Campbell for the compilation of the bibliography during this past session, and is now under similar obligation to Mr. W. J. Wilson.

Advertisements in the Journal. Advertisements of firms interested in the Petroleum Industry may be inserted in the Journal. Application for terms, etc., should be made to Messrs. Commercial Publicity Service, Ltd., 58 Warwick Street, Regent Street, London, W. 1.

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PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that Members of the Institution send information regarding their movements to the Secretary for insertion under this heading.

Mr. H. WYNDHAM JONES has joined the staff of the Caribbean Petroleum Company, Caracas, Venezuela.

Mr. F. E. KEEP is with the Messrs. Govindjee Madhowjee Company, Bombay.

Sir THOMAS H. HOLLAND, K.C.I.E., K.C.S.I., has returned home after a long stay in India.

Mr. JOHN TOWERS has returned from Trinidad.

Mr. H. F. MOON is home again from Egypt.

Mr. H. S. MOSDITCHIAN has joined the Royal Dutch Company and is with the Société pour l'Exploitation des Pétroles, Paris.

Dr. J. A. L. HENDERSON has returned to England after a visit to Canada and the United States.

It is with great regret that we have to announce the death of Mr. JOHN S. SMITH, a Member of Council, who passed away at Aberdeen on December 23rd, 1921. An obituary notice will be published in the next issue of the Journal.

Dr. A. E. DUNSTAN and Dr. F. G. REMFRY are leaving immediately for America.

A LETTER RECEIVED FROM THE BUREAU OF MINES, WASHINGTON.

Investigation work on helium, recently conducted by the Bureau of Mines, may be divided into the following heads: Helium production at Petrolia, Texas; investigation of known and of probable areas of helium-bearing gas; helium storage; helium repurification after use in balloons; and investigations of gases and liquids at low temperatures, with particular reference to obtaining data for use in perfecting methods for separating helium from natural gas by progressive selective liquefaction.

These activities have been conducted under the authority of the Army and Navy Helium Board. The funds were allotted in equal shares from the Army and Navy appropriations, and the technical work was performed under the general direction of the Director of the Bureau of Mines.

Helium storage investigations have narrowed themselves to testing the practicability of storage in mine workings. An experimental chamber was prepared for this purpose at the experimental coal mine at Bruceton, Pa., and work there is still in progress. Special field trips by engineers of the Bureau of Mines, to investigate the suitability of coal, salt and metal mines for the storage of helium, have been com pleted.

The installing of equipment in the cryogenic or low-temperature laboratory in the Interior Building at Washington, D.C., is practically completed, and liquid air in quantity is now being produced. The primary object of this laboratory is to investigate gases and liquids at low temperatures, with special reference to the separation of helium from natural gas. The scientific data obtained will be applied in the helium plants to obtain more efficient operation and to reduce cost of production.

Investigation work is being carried on along two lines, vapour-pressure work in connection with ternary mixtures and investigations relative to the purification of helium by charcoal at low temperatures.

The laboratory, formally opened by Mme. Marie Curie on May 21, 1921, is under the direction of Dr. R. B. Moore. During the past fiscal year the Army built a helium repurification plant at Langley Field, Va., using the Claude system. Dr. Harvey N. Davis, of Harvard University, was actively associated with this work. In the spring the Army asked the Bureau of Mines to take charge of the work and complete it and furnished the funds for the purpose. The plant was put under the general supervision of Dr. R. B. Moore, who placed

D. M. Ferris in active charge. The Army also transferred to the Bureau of Mines a helium repurification unit on two railroad cars, one car having the power equipment and the other the refrigeration and refining equipment. The staff of the Cryogenic Laboratory is designing the charcoal repurification unit which will be used in connection with this plant, which is also in charge of Dr. Moore.

Field investigations of possible supplies of helium in natural gas were completed during the year, every known gas field in the United States having been tested. Results were markedly successful, as they have shown that this country contains the largest supply of helium-bearing natural gas in the world.

The experimental helium plant at Petrolia, Texas, using the Jeffries-Norton process, was in operation during the year at various times, and helium was produced for short periods, yielding a product as high as 49 per cent helium. The plant, however, was not developed into an actual operating unit, and on account of Congress greatly reducing the funds for helium work during 1921 and 1922, it was decided to discontinue operations at Petrolia in July and to place the plant in a stand-by condition until further fundamental data required for efficient operation could be obtained through work on a smaller scale. In the meanwhile the larger part of the funds appropriated for helium work will be used for the production of helium in the plant erected by the Navy Department at Fort Worth, Tex., which is now in regular operation producing helium. The plant at Petrolia has been under the executive supervision of H. S. Mulliken, of the Washington Office of the Bureau of Mines, with H. F. Fisher in active charge at Petrolia.

The Fifty-ninth General Meeting of the Institution of Petroleum Technologists was held at the House of the Royal Society of Arts, John Street, Adelphi, W.C., on Tuesday evening, November 8th, 1921, Professor J. S. S. Brame, President, occupying the Chair.

The Members of Council present were Mr. H. Barringer, Mr. Arthur W. Eastlake, Mr. James Kewley, Dr. W. R. Ormandy, Mr. T. C. Palmer, Mr. Robert Redwood.

The President said the author of the paper was such an old member of the Institution and so well known to the members that no introduction of Mr. Beeby Thompson was necessary. No one was more competent amongst the members to speak on the subject of the elimination of oil-field waste, and he was sure that the paper which was about to be read would prove to be one of the most important communications which had been delivered before the Institution.

The Elimination of Oil-field Waste.

By A. Beeby Thompson, O.B.E., M.I.Mech.E., M.I.M.M., F.G.S.

No critical observer can have failed to view with concern the past and present losses of oil products during the development of oil-fields. Nevertheless, it is not easy to discriminate between legitimate and excusable losses and unjustifiable waste, for our ideas as to what constitutes waste continually change with the advance of science and the arts. It may or may not be sound economics to permit the deliberate destruction of valuable, unreplaceable minerals for which there is no immediate market at remunerative prices if a check on these losses involved the stagnation of an industry and the world's temporary deprivation of a much-needed product. Whether the immediate wants of mankind should be ignored for the sake of our successors is a debatable matter upon which financiers and economists might differ; but is it safe to entrust our future to the progress of science for discovering substitutes for resources that are limited in extent and that are not reproduced in measurable time?

No industry yields such quick returns and high rewards as the successful, if wasteful, development of oil lands, and under present-day conditions of spirited competition can investors be induced to forego a substantial proportion of their profits by adopting measures aimed at national conservation? The ideals propounded by Dr. Otis Smith in his address to the American Petroleum Institute involve such trustful co-operation and tolerance so strangely in contrast with present-day

commercial methods and international sentiment that their realization would appear extremely remote.

Carefully compiled statistics from various independent sources conclusively prove that the probable oil resources of the world are not so limitless as was once surmised, although there is no disposition to view the future with that pessimism felt by some technologists. Oil-fields do not cover vast areas like coal measures, but are represented by comparatively small and isolated pools where concentration has been induced by a combination of geological events. Existing as a liquid more or less volatile and usually accompanied by much gas, petroleum is frequently expelled with violence when its source is tapped by a bore-hole. The contained gas constitutes the agent of expulsion. It is this circumstance that enables gas and oil strata to be so quickly deprived of their flush contents instead of having to adopt laborious, lengthy, and costly mining operations as in the case of solid fuels. This condition leads to great waste.

In the development of no mining industry has such waste been witnessed as in oil-fields. This is the more lamentable for whereas, in most types of mining, uneconomical extraction does not necessarily entail ultimate loss of minerals, in the case of petroleum all unrecovered products are permanent losses. Unused gas is dissipated into the atmosphere, and uncollected oil is incapable of commercial reconcentration.

In this paper attention is called to the chief sources of oil-field losses and waste, and a brief description is given of ways and means of reducing losses, improving extraction ratios, and lowering costs. The subject is a difficult one to handle, for besides loss of products, waste includes waste of time, labour and materials as a consequence of ill-directed effort or competitive activity. No solution appears imminent for eliminating certain classes of waste unless competition is removed, but as competition is the essential driving force of industry and the incentive of invention and initiative its substitution by other tactics might tend to stifle progress.

Petroleum mining is admittedly speculative and rendered more so by great fluctuations in the market value of oil products. Financiers entrusted with funds placed at their disposal by the venturesome or enterprising are morally bound to spend that money to best advantage irrespective of whether it inflicts hardships or entails waste of natural resources. Unless specific restrictions and obligations are originally imposed by the lessors on the methods of working, shareholders would reasonably object to the deflection of funds from highly remunerative duties to less profitable practices of economy. Whilst the rapid but wasteful development of petroleum affords such large profits compared

with subsidiary works aiming at economy and conservation, operators will very reluctantly invest their funds in these latter measures before the principal losses have been sustained.

If the public demands a cessation of waste the public must be generous enough to pay for it. Governments themselves must take the risks that companies decline and provide for those lower profit-earning installations that will reduce waste. They must be prepared to adjust abuses arising from antiquated systems of leasing, support research, and finance or subsidize, or guarantee capital and interest on funds invested in schemes directed towards the laudable object of conserving national or international resources. Even then the sympathetic co-operation of the producers is essential to success. Without mutual confidence and friendly intercourse, endless difficulties and objections would be raised by enforcing works which might delay production, restrict output, or cause some slight advantage of one group over another.

In co-operation probably lies the main hopes of a betterment. Incalculable savings would result from co-operation in such works as Transport arrangements, Power Generation and Lighting Stations, Water Supplies, Vacuum Plants, Topping Stills, Gas-gasoline Extraction, Oil Storage and Pipe Lines. The unnecessary multiplicity of steam, water, oil and gas mains on any large congested oil-field is positively ludicrous, and a reflection upon human intelligence. Duplication of small, inefficient power stations, electric-lighting plants, and electric cables, leads to a waste of plant, labour, and energy that is appalling in its magnitude. If only small oil-field holdings were united instead of being separately worked and the oil product pooled and distributed in proportion to acreage owned, enormous savings in drilling plant and administration expenses would result. In the Baku oil-fields of Russia no less than ninety-two wells have been sunk on a single twenty-seven acre plot. It is not suggested that the policy was wrong, nor is it denied that the conditions were exceptional, but one could fairly safely affirm that under rational conditions one-third to one-fourth of the number would have achieved the same results at a saving of around £300,000 on wells, another £300,000 in cost of production, and over £30,000 in plant. Probably not less than £20,000,000 were unnecessarily spent in developing the Baku oil-fields owing to the conditions of leasing and the rivalry of operators.

Oil-field losses and waste are material and financial, but, as uneconomical working nearly always entails increased use of fuel for the attainment of a specific production, the two merge into one another. It is perhaps best to distinguish between underground and above-

ground losses. Underground oil losses arise from such factors as uneconomical location or spacing of wells; passing oil and gas sources of questionable value in search for more prolific; failure to exclude water from oil and gas sands, either unnoticed or temporarily neglected; unsuitable or incomplete extraction methods.

Above-ground losses result from uncontrolled gushers, soakage, and evaporation of oil, uneconomical method of extraction, and negligent handling of wells and production.

Development Waste.

Competitive drilling on leases of restricted dimensions has caused one of the most glaring examples of wasted expenditure and energy on oil-fields. In such oil-fields as those of Baku, *Russia*; Yenangyaung, *Burma*; Spindle-Top, *Texas*; Cushing, *Oklahoma*; Moreni and Bustenari, *Roumania*; Boryslav, *Galicia*, millions sterling have been unnecessarily expended in waste drilling enforced by the small area of individual differently owned leases. Owners of plots with common boundaries realize that if they fail to offset each other's wells the active one will benefit at the expense of the inactive. Offset drilling is such a recognized principle of oil-field practice that, on grounds of equity, land-owners in America have obtained judgment against lessees who failed to offset wells drilled near the boundary by neighbouring operators, but this practice is confined to the less-productive palæozoic oil-fields where drilling is usually inexpensive and quick.

Not less than eight hundred wells have been drilled on an area of about one thousand acres in the Bibi-Eibat oil-field of Russia, and over five thousand wells in the Balakhany-Sabontchy oil-field of Russia on about 2500 acres, an average of about 2 per acre. On 640 acres at Yenangyaung fully one thousand wells have been drilled or 1·56 wells per acre owing to the peculiar hereditary ownership of well sites with a diameter of 60 ft. only. At Bustenari and Moreni, *Roumania*, and Spindle-Top, *Texas*, drilling has been nearly as congested, due to the subdivision of farm or peasant lands, yet it was perfectly obvious to anyone that a mere fraction of the number of wells would have exhausted the region just as completely.

Spirited rivalry, engendered by antagonistic offsetting, often detracts from efficiency in deflecting the energies of those with limited resources from regular and more judicious operations. The yearly waste of machinery, man power, fuel, and casing through failure to adopt co-operative measures in the development of oil resources is enormous, but only force of circumstances or official interference is likely to change materially an attitude which must be regarded as one of the necessary evils of business competition.

Petroleum is the only mineral fluid mined—no other mineral can be induced to travel underground; consequently, ordinary mining laws cannot be applied to petroleum. One 27-acre plot of land in Baku has yielded upwards of 60,000,000 barrels of oil, equal to a depth of 287 ft. oil. Such a quantity has obviously been largely drawn from neighbouring inadequately developed or unworked properties, whose ultimate yields would be correspondingly reduced. On plots one acre or two in extent in Burma and Roumania have been sunk wells which have yielded 100,000 to 1,000,000 tons of oil obviously drawn from the holdings of others less fortunate or less speedy in their efforts; yet the law provides no remedy for this robbery of other peoples' subterranean wealth as there are no accepted means of equitably distributing the output or justly compensating an unenterprising or negligent proprietor.

Another evil of competitive drilling arises from the anxiety to raise oil to the surface. Immediately oil reaches the surface it is subjected to a whole succession of influences that incur constant losses. The best and cheapest storage is the earth, in which it should be left till wanted and not left for months in tank storage.

Competitive drilling likewise discourages cautious operations in anxiety to be first down to a virgin source. Upper less-productive sands are often disregarded and imperfectly protected from gas losses or water admission. The writer can well remember when no Baku well was placed on the production list that failed to give thirty to forty tons daily, and this same policy has operated in other fields where large flowing wells were always possible at some depth in a thick series of measures.

As gas will travel much quicker than oil through sands a too-rapid depletion of gas pressure in an oil-field is probably highly detrimental to ultimate yields. Congested drilling is therefore uneconomical as it necessitates the use of artificial means of extraction long before they would otherwise be needed, and leaves behind oil deprived of its own expulsive power.

Freedom in the selection of well sites unhampered by consideration of boundaries would lead operators to locate their wells away from the crest of anticlines and the apices of domes where the gas has largely concentrated, thus preserving pressure and utilizing to the full the expansive force and transportation power of the enclosed gas.

During the drilling of oil and gas-wells, sources of one or the other, or both, may be penetrated, but not considered of sufficient importance to exploit at the moment. When drilling for oil, both gas and water sources may be struck, and for years no very formidable efforts were usually made to isolate gas beds and protect them from invasions by water, or to seal them off and prevent their escape or loss. Now it is

usual or compulsory to safeguard strata so passed, as powerful gas sources which were formerly thought to be uncontrollable can be dealt with. In some countries enormous volumes of gas were allowed to escape before drilling could be continued to oil sources beneath. Such was the case in many of the American, Borneo, and Russian oil-fields where hundreds of millions of cubic feet of gas have been allowed to pass into the atmosphere before deepening was undertaken or considered possible.

It has now been proved possible to suppress, exclude, and pass the strongest oil or gas sources with the aid of a thick mud fluid. This method has been fully described in the U.S.A. Bureau of Mines Publication, *Bulletin*, *No.* 134, so need not be here described.

When undertaking such work it is essential that the casing should be securely anchored or the whole column may be blown from the well. By means of mud, wells of very high pressure have been suppressed and gas that would otherwise be lost has been saved.

In those fields where heavy flows of oil or gas may be expected, and the strata are of an unconsolidated nature, it is advisable to cement in the columns before penetrating such horizons. Failure to do this, or failure in its execution, has resulted in fabulous losses. The original well at Grosny, sunk by that far-seeing oil pioneer, the late Mr. Alfred Suart, flowed unrestricted for years after defying all efforts to effect its control. Wells at Caddo, Louisiana, have been converted into great seething lakes of gas-agitated mud, and the Dos Bocas well of Mexico not only exhausted an oil-field, but is to-day one of the most impressive and fascinating sights an oil engineer could witness. The site of the well is now a great lake of hot mineralized water kept in violent ebullition at many points by the escape of volumes of hydrocarbon gases whose sulphur odour can be detected for many miles on the leeward side. A river of water flows from this great crater which is ever extending its dimensions by the disintegration of the cliffs that now compose part of its edge.

The losses of oil due to incomplete recovery are only beginning to be appreciated. Many estimations of oil-contents have been made, based upon the porosity and volume of the oil-containing sands, but all were admittedly approximate as sand lenticles vary much in dimensions and effective porosity, and they contain barren patches whose extent there is no means of ascertaining. All calculations, however, lead to the belief that only a small part of the oil-contents of sands is recovered by the ordinary methods of extraction. A 10 per cent average volumetric content was generally assumed for oil sands, but there are few oil-fields which have yielded more than a fraction of this. The Baku oil-fields have yielded a volume of oil equal to about

3 per cent of the average thickness of the developed measures. If oil sands composed an average of one-fifth of the series the yield would be equivalent to 15 per cent by volume of the sands, but unquestionably much oil has been drawn from a wider area than that developed by wells, and millions of tons of oil still await recovery. No other oil-field has approached this yield of around 60,000 tons per acre. The old Moreni field of Roumania has given about 30,000 tons per acre. The great Kern River field of California is estimated to have yielded but little more than 1 per cent of the estimated volume of the oil sands and coalings less than 1½ per cent.

An effort to determine the unrecovered contents of oil sands was made by J. O. Lewis, of the U.S. Bureau of Mines, who compared the relative productivity of oil and gas-fields. He reasonably assumed the state of adjacent oil and gas-fields to be essentially the same, and that gas sands presented the same general features of lenticularity, porosity, and irregular impregnation. From figures collected covering 2,000,000 acres of oil lands with 179,000 wells and 1,400,000 acres of gas lands it was estimated that gas sands yielded up their product about thirty times as fast as oil sands and far more completely on account of the reduced friction and capillarity and its consequent free escape.

From other figures collected in the Oklahoma oil-fields covering a vast acreage, the fact was deduced that oil lands yielded 2000 barrels of oil, and gas lands 7,500,000 cubic feet per acre, or reduced to bulk at estimated pressure 33,500 barrels per acre: that is sixteen times as much volume as oil-content. Even if liberal allowances are made for gas in a liquid form in the earth, and the fact that the oil-fields are still far from exhausted, that much oil has been lost and gas may have travelled further than oil; the relative volumes are so disproportionate that one is led to the conviction that vast quantities of oil remain unabstracted and unrecoverable by present-day methods. The fact that gas *even under partial control* on lightly drilled territory is yielded at a rate thirty times as fast as oil tends to create that stagnant, lifeless condition of the oil-beds that operators should try to avoid.

Abundant evidence of the quantity of oil remaining in the sands is found when drilling new wells through upper, commercially exhausted oil sands, those struck being often saturated with oil readily removable by solvents or sometimes by washing with water. Often good yields of oil are obtained from pockets or lenticles which have escaped drainage by previous wells in the vicinity. In 1920 the old Pennsylvanian oil-fields were being redrilled with astonishing results, proving that the former distribution of wells failed frequently to do more than take off a flush production, and that quite important accumulations were missed by an assumed economical spacing of wells.

Finally, there is the very interesting and unique example of the mining of the much-drilled Alsace oil-field where large productions are being obtained from headings driven along the oil-soaked and still undrained sands, no longer capable of economical development by drilling.

In face of the above facts and the knowledge that oil sands capable of 10 to 20 per cent effective saturation have yielded often only 2 to 3 per cent, one is forced to the conclusion that the oil-fields are far from exhausted when the drilled wells fail to give a profitable production of oil, and with this knowledge various schemes have been devised for artificially stimulating the contents of oil sands and recovering their dregs. The following methods are possible :—

(*a*) Washing out the oil sands with water or solvents.

(*b*) Applying a vacuum to wells.

(*c*) Activating the oil or expelling the contents with compressed air or gas.

(*d*) Fracturing the oil-bearing sands by explosives.

(*e*) Mining the oil measures.

(*a*) Oil strata can be, and frequently are, naturally scavenged by unintentionally admitted water with highly successful results. Some of the older oil-fields owe their present substantial yields to the entrance of water into the oil sands in which it circulates and disengages oil during its movement towards points of extraction. But the process has been carried further by deliberately admitting water to the oil sands at strategic points where, in its passage to spots where the fluid gradient is depressed by pumping, it carries the dregs from the largely exhausted oil strata. Much more work would have been undertaken in this direction were it not for the difficulty of securing the co-operation and agreement of a number of independent operators in a district. As some areas would derive benefit at the expense of others which would undoubtedly sustain loss, some mutual distribution of benefits would appear a necessary preliminary.

With the knowledge that water has been such a powerful instrument in the past formation of oil-fields, it is certain that it can be usefully employed again as a transportation and concentration agent. There may be cases where improved results would be obtained by heating the water before admission, and there may come a time when solvents will be admitted to the sands through carefully placed boreholes for extracting oil that cannot otherwise be reached, the solvent being recovered for re-use on a continuous principle.

(*b*) A common method of reviving oil properties is by applying a partial vacuum on the wells. Obviously any reduction of pressure would relieve resistance and tend to induce a greater inflow of oil or gas from beds already largely depleted. The introduction of an exhauster generally proves beneficial when the conditions are favourable, but where badly completed wells admit air or water no improvement may ensue, and, indeed, even damage may result. A great stimulus has been given to the processes in many fields by the advance in gas-gasoline processes, as the application of a vacuum induces the volatization of light products which not only constitute an expulsion agent for the ejection of some of the remaining oil-contents but enrich the gas for gas-gasoline extraction.

Increased oil yields of several hundred per cent are not uncommon on Oklahoma properties provided with exhausters, whilst at the same time the gas may contain as much as 6 to 10 gallons of gasoline per 1000 cubic feet and be sold at 2 c. per 1000 cubic feet less than the market price of gasoline per gallon, i.e. with gasoline at 20 c. per gallon gas would be sold at 18 c. per 1000 cubic feet.

In some cases the eventual efficiency of a vacuum has been questioned owing to the suspected deposition of solid hydrocarbons in the pores of the sand as a result of the vaporization of the lighter hydrocarbons which assisted in holding the solid paraffins in solution. This may be so in some areas, but the immediate advantages of the process are too obvious to cause such speculations to modify a process of undoubted merit.

There are fields of the congested type where the introduction of a vacuum would not only be beneficial but save waste in drilling and waste of oil, but its introduction is officially discouraged owing to the losses that would accrue to those financially unable to bear the expense of its immediate installation, when others not so embarrassed could push their plants ahead and deflect oil towards their lands from those of neighbours.

(*c*) Compressed air has been utilized with success for re-vitalising oil sources. Under suitable conditions the yields of properties have been increased several hundred per cent. Oil will absorb considerable quantities of air at high pressures, and the so-called Smith-Dunn or Marietta process was partly based on this property. Air admitted to strategically placed wells under suitable geological conditions serves to disentangle oil which natural forces fail to disengage from the sands and to transport it to points selected for abstraction.

Moderate volumes of air at 150 lb. pressure have sufficed to scavenge the beds in some cases, but in other trials the introduction of great quantities of air failed to cause improvements or lead to a mounting up

of the pressure. In some "*tight*" sands only comparatively small volumes of air can be induced to enter the beds even at a very high pressure (500 lb.), and in such cases substantially improved yields have been obtained by releasing the pressure after a period allowed for absorption by the oil.

The chief objection to the process is the tendency of the air to follow lines of least resistance, usually the more porous and exhausted seams of the sand or the former feeder system to the wells. Not only does this bring about short-circuiting but the air traverses those sections of the sands most deprived of their oil-contents instead of penetrating the less-drained portions of the bed.

By changing the point of admission it is often possible to reduce the extent of by-passing and thus improve the rate of extraction.

(*d*) Torpedoing has long been practised in oil-fields where the oil is more or less sporadically distributed in compact sandstones or where the sands become choked in course of time. Under such conditions it is often possible to obtain supplies of oil only by fracturing or shattering the rock with the aid of high explosives. Channels of egress are thus formed radiating from the point of attack, so enabling oil and gas from a wide area round to gravitate or to be forced to points of relief. Successive charges at intervals after periods of production will frequently give renewed life to a well.

Little application has been made of this method of breaking up compact oil sands outside America owing to the dangers attending the use of nitro-glycerine, the only really suitable explosive till recently developed. The annual death-roll of persons engaged in the manufacture and transport of nitro-glycerine and in the shooting of wells is so large that there is good reason for the hesitation in extending its use. There is, however, every prospect that the firing of high explosives would be very beneficial in many oil-fields where the oil is erratically distributed in indurated sandstones that yield rapidly diminished productions after a good initial flow.

New interest now attaches to the problem in consequence of the use of equally violent explosives that can be made by mixing products that are harmless before mixing and present no danger in the process of mingling.

(*e*) At first, though the mining of oil would appear an absurd suggestion, yet, through the initiative and confident optimism of M. Chambrier, the Alsace oil-field is being profitably operated by shafts and headings. The Alsace fields certainly present certain very favourable conditions that have rendered the method successful, but the all-important factor is that oil sands exhausted by drilling are to-day yielding large and sustained yields by tunnelling. M. Chambrier has so

admirably described this work in his paper to the Institution that the subject need not be further discussed.

Although equally good conditions for mining oil-fields may be scarce, it would be folly to disregard possibilities which have in one case proved economically sound.

Extraction Losses.

Every field, and indeed every well, is a problem in itself not only worthy of investigation, as a rule, but inviting an interest that years of field practice only serve to stimulate. Unskilful development methods involve financial losses if not actual material losses. By lengthening unnecessarily the period of extraction the cost of production is raised and the standing charges spread for a definite output over a longer period. But there are often material losses by failure to adopt processes that will facilitate the expulsion of the oil from its source. Delays in taking full advantage of opportunities may result in the evolution of gas without performing adequate duties and the consequent permanent retention of isolated bodies of oil no longer recoverable.

Waste of resources and oil may result from inattention to one or more of the following features :—

(1) Failure to control flowing wells.

(2) Failure to adopt methods that ensure maximum extraction in minimum period.

(3) Plugging of the well by debris.

(4) Plugging of the well by paraffin wax or mineral salts.

(5) Improper handling of water gaining admission to well.

(6) Over-pumping or producing. (Excessive rate of extraction.)

(1) The effective control of flowing wells is not always a simple matter. Amidst some conditions the total closing in of a well will cause oil and gas to be expelled outside the casings or even through fissures in the earth for a wide radius around. In other cases the admission of oil is entirely checked, and in some cases no subsequent operations have succeeded in re-establishing an entry of oil. One such case came prominently before the writer's attention in Peru, where the shutting in of a large gusher resulted in the permanent exclusion of oil. Such cases probably arise when the oil is derived from a fissure system, and the high closed-in gas pressure forces clay debris into the cracks from which the oil issued. In Mexico, Texas; Russia, Grosny; Cali-

fornia, and Trinidad examples of the forcing of oil and gas around the casings have occurred, the first three cases causing serious results.

Russian wells were generally allowed to run wild, the owners resting content to deflect the vertical jet by pushing over the well-mouth cast-iron or hard wood blocks. Other control measures generally ended in disaster owing to high pressures and the large diameters and poor quality of the riveted type casing. It is in Mexico that the most elaborate arrangements are made to control the flow of the great gushers which follow the perforation of the dolomitic limestones at strategic points. Some distance above the anticipated productive stratum the casing is cemented in position, and before drilling in arrangements are made for securely anchoring the final column. Wells of 50,000 to 100,000 barrels daily capacity are thus shut in with very little loss.

When large flows are anticipated it is always advisable to drill with an oil saver or in rotary drilling a blow-out preventer, so that in case of an unexpected flow the oil can be led away under control. Unless passed through separators the oil from flowing wells loses a large part of its volatile and most valuable constituents in spray and evaporation.

(2) The best method of extracting the maximum quantity of oil in a minimum time depends entirely upon local circumstances. It is sometimes possible to extend the period of natural flow by inserting a smaller string of casing and sealing the annular space between the two columns. The introduction of air or gas may produce the same results, but eventually a stage is reached when some more permanent system of extraction must be installed for artificially raising the oil. One of the following methods must be selected :—

(*a*) Pumping, single or multiple.

(*b*) Bailing.

(*c*) Air-lift or air expulsion.

(*d*) Swabbing.

(*a*) Pumping is usually the most economical and satisfactory method where the wells do not yield more than a few hundred barrels daily and there is not too much sand or detritus entering with the oil to cut the plungers and barrels. A size of pump barrel can be selected to suit the yield of the well, and the stroke allows a further adjustment of capacity. Where limited quantities of loose sand accompany the oil and ordinary cup leathers sustain too much damage to be useful, long, hollow,

steel plungers have proved efficacious, especially when a heavy viscous oil is being pumped. The too frequent destruction of "cups" causes so many stoppages for "pulling" that some other method of extraction may have to be sought, but before discarding the pump it is well to try various kinds of "cups," some compositions resisting certain classes of wear better than others.

Sometimes the action of the pump is impeded by gas which prevents the valves seating properly. Various special well pumps have been introduced for overcoming this difficulty, but the trouble may often be quite overcome by attaching an outer piping over the barrel so that the oil has to pass down between the two before entering the lower valve. Improved yields sometimes result from shutting in the well between the pump tubing and the well casing, so either directing all the gas into the pump barrel or banking up the pressure on top of the oil column. At other times this causes lower yields. Intermittent pumping may give as good results as continuous running without the attendant cost of power and wear and tear of plant. Some wells may be pumped dry, others suffer in consequence and must be so arranged to always maintain a certain column of oil.

Light pumpers giving little trouble in cleaning may be pumped by jerker lines in groups of ten to twenty from a central power at extremely low cost. Deeper wells needing frequent attention may necessitate the installation of a separate pumping frame or the retention of a rig and engine at each well for operating tools from the beam. It will thus be seen that there are many factors to be taken into consideration when planning even a pumping scheme, and much close, intelligent observation is necessary to secure the best results.

(*b*) Bailing is a method only adopted in circumstances where other methods are practically impossible. Its employment is enforced in cases where much sand accompanies the oil, the level of liquid is low, and the well needs constant cleaning out to permit the oil to enter freely. This system reached its highest development in Russia where bailing drums of 16 feet circumference were used and bailers up to 14 inches in diameter were raised at a velocity attaining at times 1500 feet a minute. From Baku wells 100 to 200 tons of oil were often raised daily, often mixed with an equal weight of sand, and perhaps as much or more water. Engines indicating 150 h.p. were used for the work.

Even such an apparently straightforward operation as bailing yields surprisingly different results in the hands of an indifferent compared with a skilful observant attendant. Close observation and detailed records of results will disclose an economic speed of running, diameter and length of bailer, ratio of top to bottom trips, that will keep the

well free from water or sediment whilst not encouraging too great an influx of gas, sand or sediment. If such ascertained conditions are changed the yield of oil will suffer; indeed, long, tedious cleaning operations may be enforced that throw the well out of commission for days.

Deflected wells can be bailed by means of bailers in sections connected by a hollow ball-and-socket joint. Flexible metallic tubing is equally useful, but heavier, and so more expensive in power.

Wells containing a high level of gas-charged liquid, to the bottom of which frequent descents of the bailer must be made to remove collections of sand or accumulation of water, suffer much in output through the partial ejection of the contents of the bailer on its emergence from the liquid. The super-saturated oil is often expelled with almost explosive violence by the evolution of dissolved gas as the bailer emerges from the liquid and the pressure is released so that the bailer on reaching the surface only contains a fifth or even a tenth of its capacity. This difficulty has been mastered by an ingenious type of upper valve which remains open on the descent but closes when the bailer is raised. Any dangerous excess of pressure is relieved by a small subsidiary valve in the main valve held on its seating by a spiral spring.

Outside Russia scientific bailing is not understood. In Roumania it is largely practised on a smaller scale, but there are many tertiary oil-fields where improved yields would result from its introduction. It is the only successful method of extracting oil from wells where there are low levels of liquid and constant large influxes of sand and other detritus. In the heavy oil-fields in which the initial gas pressure has disappeared it performs the much more valuable duty of inducing the entry of sand by suction and so causing a larger filtration area or sump into which the oil from a wide area can more freely gravitate. The word "gravitate" is designedly used to describe the movement when the useful gas contents have escaped. Only those intimately acquainted with the unconsolidated tertiary type of oil sands can fully appreciate the significance of the above remarks. It is those wells which give the most sand that become the largest and longest-lived producers, and failure to encourage the entry of sand leads either to loss of oil or needless expenditure on duplication of wells. The occasional practice of screening wells in such strata or introducing other means to resist the entry of sand merely to permit the employment of some pet scheme of production is extreme folly. It is necessary to face the situation and adopt measures best suited to the occasion.

(*c*) Air-lift is particularly applicable to wells that have a combination of high level of liquid, large productive capacity, and small diameter where basal water collects or sand is suspended in the oil or accumulates

to the detriment of production. Such wells do not admit of pumping, adequate bailing is prevented by small dimensions, but air-lift will perform all that is required. The technique of the process has been so fully described recently by Mr. Robert Stirling's exhaustive paper that no repetition is needed.

On many oil-fields there are wells developing no abnormalities where air-lift would cause a much greater yield within a fixed time than any other simple method of extraction, and it is strange that greater use has not been made of this application to take off flush production. Neither pumps nor bailing could so well deal with such a situation. When used with light density oils, there is often a heavy loss of the light constituents of the oil unless carefully trapped or treated by an absorbent plant. Sometimes gas is used instead of air when in the circuit gas-gasoline can be abstracted at little extra expense.

(*d*) Swabbing is commonly practised in oil-fields for cleaning out wells during drilling, but as a regular method of extraction Galicia alone can claim the distinction. Drillers usually improvise swabs by winding a wrapping of hempen rope around the bailer valve, but with some outfits swabs are supplied with rubber discs. The process became general in Galicia on account of the greatly increased yields of wells following the removal of the paraffin wax, which less violent methods failed to achieve. Both the wells and the pores of the sand became plugged with solid paraffins, and wells abandoned as exhausted were converted into large producers by its use, and others giving but a barely remunerative quantity of oil had their yields raised several hundred per cent. Those who have never seen properly conducted swabbing fail to appreciate its peculiar merits and advantages over other systems. It is, in reality, an intensified form of bailing in which the bailer suction is greatly exaggerated, and much disturbance is excited in the oil-containing strata.

The cases when swabbing could excel other systems are the following, provided that the yield of oil is fairly large and the source when opened is lively :—

(*a*) Where paraffin wax is freely deposited in the well, on the casing, and in the pores of the oil-bearing bed.

(*b*) When the oil sands have frequent partings of clay or shale and the entry of oil is sluggish and the well always dirty.

(*c*) When quantities of clay or mud are brought into the well with the oil.

(*d*) When there is a high level of liquid and free entry of oil to replace that abstracted and compressed air is not available.

Skilful swabbing needs perhaps more intelligent direction than any other process. Each well must be studied individually and its maximum yield will depend upon such details as :—

(*a*) The size of swab.

(*b*) The velocity of swab.

(*c*) The number of swabs in intervals of time.

(*d*) The depth to which the swab is lowered.

Into wells of larger diameter than six inch a 4 to 5-inch swabbing column of casing should be lowered, preferably of a flush-jointed or special type to reduce wear of swabs.

Velocities up to 2000 feet per minute have been used in the 5000 feet wells of Galicia, but satisfactory results can be obtained with swab speeds of 500 to 1000 feet per minute. The best type of swabs developed in Galicia are fitted with one or more thick rubber discs, above and below which are placed helical springs to expand them and to reduce shock. When lowering the oil passes through the hollow swab stem, the top of which is machined to take a ball valve that closes on the upward movement of the swab. Beneath is attached a heavy sinker bar to ensure descent and verticality; and above is affixed a set of jars and a rope swivel coupled to a $\frac{7}{8}$ or 1-inch steel wire line. Typical double-cylinder hoists of 250 h.p. with signal and depth indicator complete a plant of creditable workmanship.

The operation of swabbing performs much more than the mere lifting of a dead column of oil. Certainly the first few swabs may be little more, but the sudden lightening of a body of liquid by the equivalent of 100 lb. or more causes with light-density oils so violent an evolution of gas from the saturated oil beneath the swab that its momentum carries it upwards faster than the swab and the column of oil above the swab is frequently ejected long before the swab reaches the surface. Sometimes the swab brings up a small secondary flow after an interval of quiescence. Even then a rush of gas will commonly follow the exit of the swab instead of a vacuum, or if the swab be left in the well gas will blow through the valve. These induced flows may be accompanied by the ejection of much sand, silt, and stones drawn from the oil beds and expelled. No surface-induced vacuum, pumping, bailing, or air-lift can effect the same result, and for that reason it is the more remarkable how little this often useful method is overlooked when such problems arise.

In some recent experiments where misgivings were felt concerning the rapid fall off of production, swabbing was introduced. In one case a well which had been unsuccessfully bailed, pumped and cleaned after

showing up fairly well gave but a few barrels daily. By swabbing with an improvised plant the yield steadily increased to 200 barrels a day and the well gave good flows at each swab with much sand, shales, and stone. A second well practically ceased to yield after producing about 16,000 barrels in four months. Repeated cleaning, bailing, and pumping failed to cause any improvement. Swabbing was instituted, with the result that a readmission of oil was gradually induced and the well gave good flows at each swab. The production rose to 250 barrels daily and the oil was accompanied by much sand and shale derived from the breaking down of the oil-bearing sands with its shale partings.

The value of swabbing was realized in the New Texas oil-fields where its use is said to be extending, and in the Grosny oil-field of Russia the process was largely employed.

Neglect to adopt the most economical process of extracting oil therefore involves direct waste of time, labour, fuel, machinery, and often indirect loss of oil itself. The relative cost of production can only be gauged by comparing the value of plant at a well and the fuel consumption and labour costs with the production obtained. Thus, a pumping well may be one of a unit of ten producing 10 barrels daily at a very low cost, but if the yield can be increased to 100 barrels daily by a process that involves say four extra men, an additional 10 barrels of oil fuel daily, and depreciation on another £1000 worth of machinery, the balance may be enormously in favour of the change.

A particular well gave 8 tons by bailing and 40 tons by air lift. The labour remained about the same, the machinery values were somewhat higher for air-lift, but there was no expenditure on belting and wire lines, and the additional fuel used was about 1½ tons daily. Valuing oil at 30s. per ton the position is as follows:—

	£	s.	£	s.	d.		£	s.	d.
Value of 8 tons oil at	1	10	12	0	0	Value of 40 tons oil .	60	0	0
Bailing costs . . .			4	0	0	Air-lift costs . . .	6	5	0
			£8	0	0		£53	15	0

Although working costs are 60 per cent higher the net returns were nearly seven times as great.

It is impossible to make a comparison of extraction costs generally applicable.

(3) Many wells fall off in yield owing to the plugging of perforations in the casing or plugging of the bottom of the well. When multiple pumping is adopted and only a pumping jack is left over the well there

is a disposition to leave wells for long periods, and often the pump has to be raised higher and higher to avoid being submerged by the accumulated debris. Obviously these conditions have an injurious influence on production. The cleaning of wells in this state often leads to a largely increased yield. Screens or strainers are very apt to become choked when shale overlies the sand, and a thorough flushing with a powerful water or oil jet may cause a great improvement. The use of bailing, swabbing, and air-lift for dealing with dirty wells is treated in preceding paragraphs.

(4) Paraffin wax is often precipitated in oil-wells and may in course of time entirely clog the well or perforated casing. Wells suffering from paraffination should be cleaned out with tools, but if this fails to induce the re-entry of oil on the scale expected the well should be steamed or heated by lowering a hot billet of steel or using scrapers or one of the electrical heaters. A few years ago there were enterprising operators who undertook to treat wells in the Pennsylvanian oil-fields in exchange for half the increased yield of oil. They were well repaid, it is said, for their initiative, as greatly increased productions were obtained from wells many years old. The value of swabbing has already been alluded to. Where much gas is present oil or gas-well waters may become so concentrated by evaporation that their contained salts are deposited, and in "tight" sands choke up the pores of the stratum. A shot in such cases would cause a great improvement.

(5) So much injury has followed the influx of water into oil-fields that its appearance in a well is always viewed with concern. Formerly it was difficult to prove whether it found admission from upper imperfectly isolated water sources or entered with the oil, but there are now recognized ways of tracing its origin. When doubts are entertained as to quantity it is customary to make periodical measurements of both oil and water yields, so that their relative quantities can be noted. By graphing the water and oil contents over a period the relationship will be seen at a glance, and the importance of the water made obvious.

Waters met with in drilling are now usually analysed and the properties of those at various depths become known. There is generally a very striking difference between upper and lower waters that enables each to be readily distinguished. By comparing the relative amount of chlorides, sulphates, carbonates and total solids, it is often possible to correlate waters between certain limits of depth, and so determine their probable origin if they appear in wells. In most oil-fields total solids, carbonates and chlorides increase as the oil sources are approached whilst sulphates diminish or disappear.

A very little water may sometimes adversely influence the production of wells, partly by imposing a resistance to the free entry of sluggish oil and partly by causing some kind of sands or sediment in the well to pack tightly. If unexcluded, overhead water with a greater static head than the oil finds ready admission; unless removed as fast as it enters, the oil will be driven back from the well by the flush of water, which in time may find its way to other wells, abstracting fluid from the same sand body. In this way innocent parties have to suffer for the negligence of the careless.

Water entering through faulty or damaged casing is often shut off by the insertion of a packer on a smaller string of casing or tubing. Its entry may often be seen in a low-level well by projecting a ray of light down the well by means of a mirror.

(6) Wells on certain fields may be overworked, especially those deriving their production from loose sediments amidst measures containing water-bearing beds. Even when the oil is derived from a compact sand and there are no dangers from water or collapsed casing, an excessive rate of extraction may induce such an inflow of gas that higher yields are obtained by less intensive measures. It is usually preferable to open up an oil source gradually by not depressing the level too much at first, and thus helping to conserve the gas for use over a longer period.

Amidst unconsolidated tertiary strata that readily disintegrate on the removal of the oil, an excessive rate of extraction may induce fierce expulsions of sand that partially fill the column and even cause falls of roof material that deflect or fracture the lining tubes. Days and weeks may be wasted in cleaning out debris thus entering a well, and in some Baku wells months have been expended in repeatedly re-drilling out material brought into the well by successive ejections of the fluid contents of the well by gas. Under these circumstances there is always a danger of overhead water breaking in under conditions that render its subsequent exclusion quite difficult.

Interesting features characterize the flow of Mexican wells sunk into the dolomite limestones. There the oil is expelled by underlying water under a high hydrostatic head, and a practically regular rate of flow is maintained through a particular sized orifice until the oil approaches exhaustion. As the body of water ascends and replaces the expelled oil along the anticlinal arches, the rate of flow must be reduced to prevent admission of water. Usually the approach of water is foreshadowed by a rise in the temperature of the oil, and its entry to the well can be delayed by reducing the rate of flow with the valve on the flow pipe.

Apparently long before the water ascends to the base of the tubing, a water cone is produced beneath the shoe of the casing through the resistance of the oil exceeding that of water. On checking the flow of oil, the water cone flattens, and large but decreasing yields of oil may sometimes be obtained for weeks after the first appearance of water. Under these unique conditions a whole oil-field could be exhausted by a single strategically placed well on a dome structure. The Dos Bocas oil-field of Mexico was so drained through accident, with a possible loss of 10,000,000 tons of oil. No other well in the vicinity has since yielded oil.

Fuel Waste.

It is remarkable how little serious attention is given to the subject of fuel expenditure on oil-fields, and more commonly than not oil fuel can be seen generating steam for purposes that could as easily be handled by internal combustion engines or electrical power. Frequently sufficient gas may be seen flowing to waste to provide all the power requirements of the property; indeed, there are few new oil-fields developed where in the initial stages any oil need be burnt. On many oil-fields the fuel consumption amounts to over 10 per cent of the production, and it will often be found that on those more prolific and new fields most bountifully provided with gas, least is in use. Power on oil-fields is generated by one of the following:—

(*a*) Steam engines.

(*b*) Internal combustion engines (gas engines, oil engines).

(*c*) Electrical power.

Steam power on oil-fields is almost universally generated in small units of portable dimensions and weight owing to the temporary character of most installations and the wide range of distribution. High efficiency boilers of the water-tube type are rarely used, as they necessitate expensive erection and better water than is often available without expensive works or treatment. Consequently the practice is to instal units of an evaporative capacity of 1000 lb. to 2000 lb. of water per hour which generate around 10 lb. of steam per lb. of oil instead of a possible 15 to 16 in high efficiency boilers.

Equally inefficient steam engines are likewise employed to withstand the exposure and rough treatment to which they are always subjected, and the steam consumption is probably rarely less than about 40 lb. per b.h.p. hr. and often 50 lb. to 60 lb. This rate of consumption is considerably exceeded in the case of duplex steam pumps such as are used for oil-field duties and mud flush pumps for rotary work. In these

latter the steam consumption is often from 150 lb. to 200 lb. per b.h.p. hr. The thermal efficiency of oil-field steam plants is usually less than 2½ per cent. So simple in construction, convenient in use, and so responsive to variable demands are steam engines, and so repugnant to drillers is the introduction of other sources of power for drilling purposes that there appears little immediate prospect of introducing more economical systems. Electrical energy can be employed, and well designed reversing gears enable oil and gas engines to be utilized for drilling, but they are unpopular and little used. If, therefore, steam must be perpetuated and small inefficient units retained, it is necessary to secure its generation at the least possible expense. This can be accomplished by the entire or partial use of gas. About 45,000 cubic feet of gas are usually equal to about one ton of oil.

Gas or oil engines can be used for most oil-field duties outside drilling, such as for pumping powers, oil or water pumps, electric lighting, workship running, and driving compressors. Gas engines cost nothing in fuel and use about 10 to 16 cubic feet of gas per b.h.p. hr., whilst oil engines consume from half to three-quarters of a pound of oil per b.h.p. hr., according to size and duty, and have a thermal efficiency of 20 to 25 per cent. They, however, need substantial foundations, good housing, and skilled or semi-skilled supervision if trouble is to be avoided.

Electrical energy is the ideal power for most oil-field purposes other than drilling, and its use is steadily extending. The chief objection is the high capital expenditure on works needed for duties of a non-permanent character, but for simplicity, convenience, and cleanliness there is no equal either in the distribution of power or character of the motors. Another objection sometimes advanced is the high speed of motors that makes it necessary to introduce gearing or counter-shafting for many purposes.

The great advantage of electricity lies in being able easily to shut off the power when not required. In practice, oil and gas engines are kept running during periods of intermission of work, and steam engines have to be kept running to avoid water accumulation in engine and pipe lines which must be drained at periods when machinery is idle. Condensation in mains proceeds and radiation of heat continues whether work is in progress or not. On the other hand, electrical stations of insufficient size to take comfortably the peak loads that are occasionally thrown on the plant are a constant source of trouble.

The aggregate annual fuel charges on oil properties are enormous, and probably 50 to 75 per cent could be wiped out by the introduction of possible economies within the financial capacity of operators. At one time over 1,000,000 tons of crude oil were annually burnt as fuel on

the Russian oil-fields, a greater part of which could have been saved by utilizing a portion of the gas that was allowed to discharge into the atmosphere.

Even if it is agreed that fuel oil under boilers cannot be conveniently replaced by gas there are still many pecuniary losses sustained by not restricting fuel to the least valuable portion of the crude. Several alternatives are possible in this connection when a high-quality crude oil is produced, viz. :—

(1) Crude can be replaced by refinery residues or low-value products.

(2) Crude intended for fuel can be stripped of its lighter constituents by a topping plant on the field.

(3) Less-valuable oils and other fuels may with advantage be purchased or exchanged on equitable terms.

All these expedients have been adopted with advantage on fields yielding a high-grade oil. Coal now frequently replaces oil, and even gas as fuel in the Appalachian oil-fields, and cheap Mexican and other low-grade oils are imported on properties to release the whole output of high-grade oils for refining.

Evaporation Losses.

The evaporation losses sustained by light oils in their field manipulation are very high, but even heavy oils and those with small volatile contents suffer material loss by negligent handling and needless exposure to the atmosphere. An uncontrolled discharge of oil from a flowing well is generally in the form of a misty spray caused by great volumes of methane which pulverize the oil. In this form the oil is particularly susceptible to evaporation and loss as spray if exposed to the atmosphere; indeed, the density of the recovered oil is frequently much heavier during the flowing period than subsequently when the gas diminishes and less of the volatile constituents are carried off. Passage through gas traps materially reduces these losses of light products. Spray losses are thereby entirely eliminated, and evaporation is reduced partly by exclusion of air and partly by the chilling effect of expanding gas in a confined chamber.

For the purpose of gas conservation and oil-field safety, gas traps are valuable oil-field adjuncts, and as preservers of light constituents their installation is often justified. With the wider introduction of gas-gasoline plants their employment is bound to extend, as they prepare the effluent of wells for the plants. Until the introduction of the McLaughlin gas separator there was no suitable appliance for dealing with large, high-

pressure wells where much sand accompanied the oil and gas, but this ingenious separator can be applied to wells of almost any capacity or pressure with little loss of either oil or gas.

Naturally the higher the pressure maintained in the separator the better the results, but whatever the pressure the transference of unagitated gas-freed, slow-flowing oil into the collecting tanks brings about those quiet conditions that make for reduced losses.

Volatile oils of light density are usually led from the wells to collecting cisterns with sealed roofs on which a weighted safety valve is superimposed to allow gas to blow off in the event of excess pressure. Even with tanks so provided the violent discharge of gas and oil that characterize the final stage of intermittent flows (flows by head), whether through the pump or the casing head, causes heavy losses by violently agitating the contents and forcing through the relief valve much oil as spray.

It would be difficult to estimate the losses sustained by allowing uncontrolled flow of wells into the atmosphere. Their extent can only be appreciated when one considers that many wells in the highly prolific fields yield 50 per cent of their ultimate production in the initial period of natural flow.

The collection of oil in open sumps is always objectionable, as dirt, vegetable matter, and insects gain access, whilst rain causes admixture of water and earthy wash, but in many oils the evaporation losses are extremely high although the actual amount is dependent upon temperature, winds, and the state of the atmosphere. So large are the ascertained losses of light density oils in storage that it is now customary to shade steel tankage from the sun's rays by erecting umbrellas or maintaining a water bath or spray on the roofs. Sun screens are likewise built around the sector facing the south in hot countries, and experiments with colours show that great savings are obtained by painting the tanks with carefully selected colours that do not absorb heat. Black and red are particularly unsuitable.

Precautions are now generally taken to avoid splashing of oil as it enters the tank; and on large tank farms vapour pipes are often led from hermetically sealed tanks to absorption or refrigeration plant where all liberated vapours are re-condensed. A suitable relief and respiratory valve must be provided to hermetically sealed tanks.

Oil-field Drainage.

Whatever precautions are taken to prevent loss at individual wells, much oil is unavoidably lost in those rich fields where the wells are closely spaced and there are successive oil horizons that may have to be

passed or tested before a trial justifies their being placed on the productive list. Often unexpected flows or gushers that break loose spray the whole neighbourhood with oil, augmenting the quantities that lie about in the sumps where the drillings are dumped. The washings on the derrick floor alone, after withdrawal of tools or a clearing out, may reach important quantities, and even in pumping wells the "pulling" of tubing or rods always causes losses. So great are these combined losses that the drainage of congested oil-fields is a valuable and much sought-after possession. Immense quantities of oil can be saved by arranging for the drainage of oil-fields to pass traps conveniently placed to strain off its oil contents, and this especially applies to their early career when natural flows are frequent and losses great. Regions subjected to heavy rains may present some difficulties, but even if the arrangements have to be by-passed at intervals during storms the losses would be insignificant compared with unrestrained discharge.

Emulsions.

A common source of waste and anxiety to oil-field operators are emulsions consisting of intimately mingled water, oil, and fine mineral particles that resist separation without special treatment. During the early development of the Russian, Californian, Texas, and Mexican oil-fields literally millions of tons of emulsified oil were run to waste or burnt in consequence of the absence of a simple means to effect separation. Even quasi-emulsions that can be treated by heating, steaming, or centrifuge were often thrown away in ignorance or to avoid trouble. True emulsions cannot be so readily broken down, and they are formed by the violent agitation of certain mixtures of water and oil in the presence of some chemical agent or minute mineral particles.

The formation of emulsions is not well understood. Sometimes they suddenly appear in wells and as mysteriously cease again after weeks or months, although the proportions of oil and water have shown no marked alteration. It is uncertain whether they occur in the earth when water and oil are in contact. Certainly in many cases they do not, for the line of separation is distinct, but in other cases the suddenness of their appearance leads one to suspect their existence. They are in some cases artificially formed as occasionally occurs in the air-lift process of raising oil, and even in bailing wells the product raised from different levels in the liquid column has shown varying characteristics that indicated the creation of an emulsion in the well. In the Mexican oil-fields, where the great gushers owe their origin to hydrostatic conditions

and water follows the expulsion of the oil, there is a period when an emulsified mixture is expelled, but even here there is no direct proof that the line of contact between the oil and water is marked by an emulsion in the earth. One case is recorded from Mexico where the emulsion was found to be formed in the flow pipe from the well, as samples taken at the mouth of the well were not emulsified.

Undoubtedly at times emulsions can be avoided by skilful handling of the wells. Thus in Baku it was often possible to ascertain by trial a ratio of top and bottom bailing, i.e. a rate of oil extraction that would yield an unemulsified mixture of oil and water. In many wells any considerable deviation from this ascertained ratio would within a few hours lead to the formation of an emulsion. The oil from Mexican wells that developed emulsion will often revert to the unemulsified form when the rate of flow is checked, and the relative proportions of oil and water changed.

There are certainly various types of emulsions whose characteristics and source have been little investigated. Those from Russian wells where the oil is of medium density ·880 had a curdled appearance like sour milk. Sometimes a yellow vaseline-like substance is formed, as in Galicia, with paraffin base oils. Some of the heavy black, asphaltic oils of ·900 to ·970 sp. gr. often contain up to 10 and 20 per cent of water that cannot be detected without special examination, and its presence may be first noted in the refinery. Much trouble is then experienced through frothing and deposition of mineral salts in the stills as the water holding the salts or solution is expelled by evaporation. In one case an oil containing 8 per cent of water with 3 per cent salts was actually depositing half a ton of solids per day, to the serious detriment of the working and life of the stills, especially as some magnesium chloride was being concurrently decomposed, forming hydrochloric acid.

Doubtless many emulsions arise from the faulty completion of wells that admit unexcluded overhead waters mingled with fine mineral matter into the oil-beds, in which case one single well may be responsible for widespread trouble. It is not, however, unlikely that Nature itself is equally responsible for many of the troubles, especially in the tertiary oil-fields where highly distorted and unconsolidated sediments are disturbed by the ejection of considerable volumes of oil mixed with sand. Then, in many cases, admitted water may play an important rôle in washing out the dregs of oil sands deprived of the gas energy that in their early period expelled the oil contents. Emulsions must, therefore, at times be regarded as necessary evils in oil-field works, and means must be provided for their treatment unless large volumes of oil are to be lost to mankind.

Quasi-emulsions, that is, merely mixture of oil and water that separate by long standing, are generally due to the high viscosity of the oil or the small difference of sp. gr. of the oil and water. Their separation can be accelerated by application of heat. Separation of oil and water mixtures can be accomplished by a centrifuge, but true emulsions do not readily admit of such easy handling. Success has attended the use of centrifuges with a rate of revolution of 15,000 to 16,000 per min.

The electrical process has so far proved most satisfactory for breaking down refractory emulsions. Oil is a non-conductor of electricity, and if a high-tension current is allowed to pass through an emulsion it follows the direction of the water globules and in the process breaks up the mixture and causes the pellicles to coalesce. If the emulsion is previously warmed, rapid separation follows, provided short circuiting is prevented by keeping the liquid in motion.

Gas Waste.

By far the greatest waste of hydrocarbon products lies in the gas constituents. In the uncontrolled passage of untreated gas from the earth to the atmosphere not only is the best form of fuel lost, but it generally carries with it liquifiable hydrocarbons capable of being stabilized and blended with heavier products. That from oil-wells often carries with it in addition to spray the most valuable constituents of the crude oil. Many of the Palæozoic oil-fields of America presented the difficult feature of gas pools overlying oil pools or of contiguous gas and oil areas where one product could not be extracted without influencing the other. When the separation is distinct, methods have been evolved that enable gas sources to be passed without great loss, but when oil and gas are intimately associated the extraction of the oil necessitates the expulsion of the gas. It is this latter circumstance that has caused the greatest loss of valuable products and introduced a problem that still awaits solution.

Many scientists are to-day working on the problem of utilizing to advantage the gas now being allowed to escape on oil-fields and for which there is no immediate use within an economic distance. Even if treated for its condensable constituents and used for all local power purposes there is often a surplus which is enormous. When situated near industrial centres or cities the gas finds a ready market, but usually oil-fields are located in remote districts where there are no other natural resources to develop and too far from large towns to repay the cost of piping or transmission of energy after conversion.

Some of the possible uses to which gas relieved of its condensable products can be put are the following :—

(*a*) Transmission in pipe lines to industrial centres.

(*b*) Development of local industries like glass-making, lime burning, cement works, irrigation.

(*c*) Generation of electric power on large scale.

(*d*) Production of carbon black.

(*e*) Fixation of nitrogen from air.

(*f*) Isolation of special constituents.

(*g*) Compression in cylinders.

(*a*) Pipe line transmission of gas for long distances is limited by capital cost of construction. Even if compressed to 45 atmospheres (660 lb. per square inch) the gas volume for the equivalent heat units would be twenty-four times that of oil, so that even if gas can be transmitted three times as fast as oil, owing to the reduced friction, gas lines need to be eight times the area of oil lines for the conveyance of the same number of heat units. Such large pipe lines as are needed to carry great volumes of gas could only be justified by certainty of regular supplies for many years.

(*b*) Many of the important American oil-fields have been followed closely by glass works in which inexpensive fuel is such an essential to cheap production. Other works such as cement making or lime burning might be erected, but usually the high capital outlay on immovable property renders the experiment too hazardous. When near lands capable of irrigation from rivers, cheap gas could be profitably employed, as fuel is generally the sole objection to such schemes.

(*c*) Even when within economical distances of industry, the generation of electric power on a large scale for long distance transmission is open to the one objection of uncertain supplies of gas to justify large capital outlay on immovables.

(*d*) Carbon black is largely produced by the combustion of gas in an imperfect supply of oxygen. It is a very wasteful use to which to put gas, as in practice only about 1 lb. of carbon per 1000 cubic feet of gas is produced, although the carbon content of 1000 cubic feet of methane is about 31 lb. of carbon. If the extraction of larger quantities of carbon black is attempted the quality falls. As the value of the produced product is only 6d. to 7d. per lb., gas must be very low in price to make its extraction payable.

(*e*) Fixation of atmospheric nitrogen is another possible use for cheap power with ample resources of raw material to work upon. The

objection here is likewise capital cost on permanent plant, but it is perhaps one worthy of Government guarantees or subsidies when a large agricultural population would derive great advantage from cheap nitrates.

(*f*) The isolation of particular constituents, such as helium, has been undertaken under special conditions, such as the war brought about. Research is, however, mainly directed towards methods of converting gaseous hydrocarbons into stable liquid products.

(*g*) Under the name of Blau gas a continental trade developed in dealing with compressed gases in cylinders. Such a purpose would not utilize the great quantities of gas usually evolved, but there may be a great development of this in the future. At present the industry is practically killed by the high initial cost and great weight of the containers. If only our metallurgists could discover a steel alloy of much greater tensile strength it might be possible to operate motor vehicles by using gas direct instead of of suffering present day leakage losses and trusting to the very imperfect vaporization of liquid petrol in a vaporizer.

All the above schemes suffer some disadvantage and are applicable only to special cases. There remains but the one feasible alternative, that of returning unused gas to the earth and re-charging exhausted sands. Gas reserves could then be created and be drawn upon as and when required. Such works would entail much careful research, a strict control of oil-field operations and public financial assistance. As power reserves for the final stages of development of oil-fields such supplies would be extremely valuable.

Gas-Gasoline Losses.

Few oil-fields yield gases devoid of hydrocarbons that can be recovered by absorption or condensed to a liquid form by compression, refrigeration, or both. During the early career of oil-fields the gaseous products may be very largely methane, but there is usually a portion of the higher homologues of the paraffin series, and their proportion increases with the development of the field. The largest amount of condensable hydrocarbons are present where a partial vacuum is applied to the wells, that is, when a field is approaching exhaustion. Subjected to pressure or refrigeration, or both, hydrocarbons whose boiling points fall below the temperatures and pressures applied are liquified, and on exposure to atmospheric conditions they do not entirely revert to the gaseous form. Generally on liberation from the high pressure condenser they boil, and the losses may be considerable, but if the lighter fractions are allowed to escape slowly without too violent agitation of the mass a varying quantity of a fairly stable product

remains. The "weathering" of gasoline products extracted by pressure is, however, a wasteful procedure, as with some gases the greater part may spontaneously volatilize, leaving but a small fraction of that produced.

It is by blending with heavier refinery distillates that the condensates of gas plants can most economically be retained and marketed. Mixed in suitable proportions with heavier gasolines they will lighten the gravity and not raise the vapour tension of the whole beyond that dictated by caution or permitted by law.

The rising price of gasoline in U.S.A. has caused those casing head gases rich in gasoline to become a valuable and most sought for commodity, and high prices have been paid for installations that had secured gas rights over large areas at low rates.

The usual compression plants consist of compound compressor units of 200,000 to 5,000,000 cubic feet per day at 150 to 300 lb. pressure, either direct or belt driven from gas engines using some of the treated gas. The compressed product is passed through a water-cooled condenser from which the condensate is automatically trapped, whilst the escaping dry gas, after being expanded in a chamber forming the last section of the cooler, is led away for fuel requirements. Only careful consideration of each individual case will enable one to say what gasoline contents can be made payable in any particular area as it depends upon the cost of collection or purchase of gas, facilities for blending and transporting the desired products, the cost of installing the plant, and the uses for residue gas. Rarely can compressor plants be profitable operated with gas containing less than one gallon of gasoline per 1000 cubic feet.

Some gases containing sulphur products cause such rapid corrosion of the valves and cylinders that the use of compressors is impossible, and at other times large percentages of carbon dioxide or nitrogen or of air, in the case of air propulsion, may render compression unprofitable even if the gas contains heavy hydrocarbon vapours. Such factors as the foregoing, together with the impossibility of profitably treating low grade gases, led to the introduction of absorption processes which are now displacing the compression and refrigeration types.

Most absorption processes rely upon the absorptive properties of certain petroleum distillates for lighter hydrocarbons, which later can be expelled by heating, and the recovered absorbent after cooling used over and over again: indeed, a continuous cycle can be maintained of absorbing, expelling, and returning the chilled absorbent.

By means of absorption, gases can be profitably treated under favourable circumstances with contents as low as 1 pint ($\frac{1}{8}$ gl.) per 1000 cubic feet. Inflowing gas under as high a pressure as possible is

allowed to meet a descending flow of suitable absorbent in vertical towers where convenient baffling is interposed to ensure intimate contact of the two fluids. The liquid from the towers is conducted to a still where, during passage through a series of chambers, its light contents are expelled by heat, and the freed absorbent is returned to the towers, being subjected to cooling in its progress. By counter flow arrangements the outflowing hot liquid is made to heat up by the inflowing absorbent. Even with this process the gasoline is often wild, and unless somewhat intricate complications are included that provide for the condensation and return to the circuit of products evolved on release of pressure much light-density petrol is lost. The process does, however, appear to yield a more stable product than compression, and varying methods of absorption undoubtedly influence the quality of the product.

One step further has now been reached by the discoveries of Mr. G. A. Burrell and Mr. Oberfell, who, by using "activated" charcoal as an absorbent, are able to obtain a much larger proportion of stable gasoline products than by any other process, larger, indeed, than that theoretically attainable by past recognized methods of testing. A polymerization of hydrocarbons has been suggested but it is likely that the difference of quality is due to mechanical features. This recent development opens up a new line of study that may influence the future of the gas-gasoline industry.

This paper is not, however, intended to discuss the details of processes, but rather to indicate the direction in which savings of oil products can be effected. At present practically no treatment of gas for gasoline contents has been undertaken on a large scale outside America. In 1919 no less than 300,000,000 gallons of casing-head gasoline were produced in the U.S., being about 13 per cent of the total gasoline production, although only a part of the gas available had been so far treated. The value of this gas-gasoline constituted much more than the 13 per cent of the total U.S. gasoline values, which later were estimated at 45 per cent of the value of all American produced oil products in 1919, although its quantity represented but 25 per cent of the crude produced. To-day about 1,000,000 gallons of gas-gasoline are collected daily from gas in the U.S.A.

From numerous tests made it is clear that the gaseous emanations of most oil-fields contain products that would well repay their extraction, provided there were convenient means for their disposal, and it is this latter feature which has probably been one of the chief hindrances to obvious savings that are annually being accentuated by the rising prices of petrol.

An effort has been made in this paper to place a rational complexion

upon the oil conservation problem. There has been a tendency on the part of economists to indulge in platitudes about oil-field conservation and waste, so that it is well at times to regard the position from the standpoint of the financier who supplies the funds and the technologist who directs the field operations. All waste is to be deplored, and is deplored by the thoughtful, yet in the struggle for existence—both national and individual—the present must take priority over the future. To a large extent we must leave our successors to work out their own salvation with what we leave them, as we have been left to work out ours with what our inconsiderate ancestors thought fit to leave us. For our own reputation, however, it is desirable that every avenue of possible economy and efficiency be pursued consistent with the exactions of capital.

In this review of oil-field losses an attempt has been made to indicate the direction in which economies can be made and to emphasize the fact that the mechanical possibilities of oil-field development are still far from exhausted. Every year the need of trained assistance becomes more and more evident, and there is no doubt that the industry has outgrown the supply of trained operators. Oil-field operations demand no less attention than other forms of mining, and in none is a greater variety of scientific subjects involved.

Without doubt the greatest oil-field losses have been and are being still sustained in hydrocarbon gases, a fuel which has no equal for clean, convenient, and economical use. Responsible Washington officials have volunteered the information that in a few years prior to 1912 not less than 425,000,000,000 cubic feet of gas were allowed to discharge unheeded to waste in the Mid-Continental oil-fields alone, equal to about 9,600,000 tons of oil or say 14,000,000 tons of good quality coal, whilst gasoline to the value of millions sterling was simultaneously lost. In 1913 a single well in the Cushing oil-field gave 1,500,000,000 cubic feet of gas equal to 34,000 tons of oil before being shut in, and four others were discharging 126,000,000 cubic feet daily into the atmosphere, equal to about 2,800 tons of oil.

In Mexico alone the gas losses during the last few years on a very conservative estimate cannot have been less than the equivalent for thermal value of 1,000,000 tons of oil, whilst the extractable gasoline contents alone have probably exceeded 100,000,000 gallons; yet the conditions were such that no practical use could be found for the gas, and the gasoline extraction involved such expense in subsidiary works that its remunerative recovery and delivery to seaboard was impossible on a scale commensurate with the industry.

If we assume an average yield of only 250 cubic feet per barrel of oil produced for oil-fields outside the United States—in which latter

country the average is more nearly eight times this quantity—and disregard entirely gas-fields, the amount of gas obtained and practically all dissipated into the atmosphere reaches the gigantic total of about 833,000,000,000 cubic feet up to the end of 1920, equal in heating value to nearly 19,000,000 tons of oil. This quantity will be better appreciated when it is recalled that oil-producing countries like Roumania, Galicia, and Burma have, in their best days, not exceeded 2,000,000 tons of oil annually. As 1 lb. of oil or 20 cubic feet of natural gas will generate in a high-class modern steam-engine 1 b.h.p. hr. the power lost represents about 42,500,000,000 h.p. hrs. Gas is being used more and more on oil properties, but, whereas in the early stages of oil-field development with flush productions the available quantity far exceeds requirements, in the latter stages the supply frequently does not approach the needs. Employment for this surplus gas, inseparable from active oil-field operations is, perhaps, the most important problem awaiting to-day a satisfactory solution. The extraction of its gasoline contents only reduces the volume of gas by about 3 per cent for each gallon of gasoline recovered per 1000 cubic feet, and the production of carbon black results in only about 3·3 per cent of the contained carbon being fixed as such.

Reverting to the power problem for oil-fields it is surprising that so little has been done in the direction of co-operative generating stations. A large modern electrical power station will generate current at about 1½d. per unit with oil fuel around £5 per ton. If natural gas is used costing a nominal sum only, the cost per unit may fall to ¾d. In one case where electrification is being undertaken it is estimated that by its use the cost of oil production will be reduced by 15s. per ton even where much gas is now used as fuel; but had no gas been used the saving was estimated to reach 24s. per ton.

Trinidad provides a typical example of the phlegmatic attitude of operators. Nowhere are the chief oil-fields separated by more than fifty miles, and a central station jointly financed by the leading concerns could be erected at some central point where plenty of gas would be available for fuel, and the power distributed not only to the fields, but to all the towns, villages, and estates along the routes followed by the cables.

DISCUSSION.

The President, in opening the discussion, said the members had heard, as he anticipated, one of the most important and interesting addresses which had been delivered before the Institution. The members of the Institution must realize that it was part of their work to do what they could to minimize some of the enormous losses

to which attention has been called, but in many cases they were powerless to do anything, it being a question of legislation. It was, however, rather astonishing that oil-producing countries should have been so foolish in allowing the condition of things to which attention had been drawn by the author ever to arise. Unfortunately, however, under the present conditions of leasing, etc., in many countries it was quite impossible to adopt methods for avoiding the enormous loss. The author suggested the difficulty might be overcome by a pooling of the interests; he suggested, for instance, that the pooling of the product and its distribution in proportion to acreage might be adopted. Personally he wondered whether, with the varying yield of oil, distribution according to the acreage would be quite a fair basis upon which to assess the relative values. Another important aspect of the question was the very large number of wells which had been sunk in oil territories. The author mentioned that in 1920 re-drilling was taking place in the Pennsylvanian field, because the former distribution of wells frequently failed to take off more than the flush production, so that there was something to be said perhaps on the other side, that some of the districts had been nearly exhausted, and that there would be no need, even if there was room, for further drilling in the future. He was most particularly interested in the question of the methods of recovering oil from presumably exhausted sands, i.e. sands exhausted so far as the flow of oil was concerned. In that connection probably the work which Frasch did in producing sulphur in Louisiana might have an important bearing upon the question of the treatment of exhausted oil sands with water under pressure, particularly heated water. Frasch conceived the idea of sending down highly heated water, so that it should reach the sulphur bed at a depth of 440 feet at such a temperature that it would actually melt the sulphur at the bottom of a boring, so that it could be raised to the surface by means of the air-lift system. He mentioned that case because Frasch was so closely connected with the petroleum industry, and because possibly the methods which he adopted with so much success, and the difficulties which he had to overcome were much the same as the methods the oil engineer might use and the difficulties which the oil-field engineer would have to overcome, if displacement by heated water was adopted, and it would very probably prove a useful method. The author said that probably the waste of gas was the most prodigious waste of all wastes on oil-fields. The economic distribution of the gas in many districts was impossible, and where gas had been used under boilers it had been very inefficient. As a rule, gas-fired boilers were inefficient. But within the last few years the Kirke gas-fired boiler had been developed, in which burning gas was drawn through long tubes, the burners were

situated a few inches outside the boiler from the tubes, and an induced draught was used, so that no brickwork, no setting for the boiler and no chimney were required, and an efficiency of 90 per cent was claimed with gas-firing. The difficulty of establishing industries in the neighbourhood of the fields was very great, because costly plant could not be erected owing to the question of the continuity of supply over a sufficient number of years, so that electricity supply from central stations or the use of power for the fixation of atmospheric nitrogen probably would not be favourably considered. But there were two directions in which they might look for the more efficient utilization of the gas. The manufacture of calcium carbide would be quite a possibility in many districts if there were adequate supplies of limestone, and the coke from the petroleum refineries might find a useful outlet in that direction. But the one line of development which he thought would be a very useful one if the commercial process could be discovered would be the production of alcohol from the natural gas. It would be rather a score for the petroleum technologist if he could produce alcohol as a by-product of his petroleum production, for they were told that that was the fuel of the future and was going more or less to supplant petrol. It had been stated that 5000 cubic feet of gas would give a yield of 50 gallons of alcohol. Personally he thought the yield claimed was excessive and bespoke a very optimistic outlook, but nevertheless it was a possibility which should not be lost sight of.

Mr. Hudson Hobden considered that waste started from the time the lease was granted right up to the time of refining. He desired to give a few instances of waste and how it could be avoided. He remembered an instance in the Elbing field where an extension was opened up some two miles south of the discovery well. The well started off with something like 2000 barrels, and there were 80 acres of land available for lease within a quarter mile of that very well. The geologist of the company had surveyed the ground very thoroughly and had condemned those 80 acres. However, a prospective purchaser in spite of this went ahead and paid 1500 dollars an acre for the lease, in addition to which 30,000 dollars per well were expended in drilling two wells, which were failures.

Passing to the drilling side of the subject, it was also a very well-known fact that quite a number of good wells had been spoiled through being carried too deep. Most of the companies operating at the present time in the Mid-Continental field had made it a hard and fast rule that as soon as the top of the sand was found all drilling must stop until the geologist made a recommendation as to how deep into the sand the well was to be carried.

The most efficient method in use at the present time was pumping with electrical power. The old system of using gas-engines with central power caused considerable trouble, not only with cut oil but also with parted rods, loss of time, loss of cups and so on. By installing separate motors to each job and pumping with electricity, it had been proved beyond all doubt not only that the production was increased but that cut oil was eliminated to a very great extent, while in addition the initial cost of the motor would be paid for inside of twelve months. The question of swabbing had been mentioned in the paper. The Empire Gas and Fuel Company, of Oklahoma, did not favour swabbing except under certain peculiar conditions, because so many fields had been spoiled through over-swabbing. The Company he mentioned had proved from experience that it was desirable to recommend swabbing only where the well had come in as a natural producer and the flow tended to drop off. Their practice was to swab for about three days in order that an opportunity might be given to open up the pores of the sand and thus make the oil flow more freely. After swabbing, the well was given a thorough clean out and then put on to the pump. Cases had occurred where an offset well had been a big producer and an operator would use a swab to try and get the benefit of the flush production as against his neighbour, but that was a system which was not looked upon with very much favour. The question relating to offsets was now receiving considerable attention in the United States. In the old days it used to be considered that a legal offset well was 200 feet from each line, but there was really no such thing as a legal offset well. A well could be drilled right on to the boundary. The law stated that if a well was drilled one's neighbour was forced, if the lessor called upon him to do so, to offset the well as close to the line as the other well was close to the line. The general impression prevailing now with regard to deep wells was that, instead of drilling nine regular locations to 40 acres, by drilling four wells, each well being 450 feet from each line, those four wells would produce as much oil and would take care of the 40 acres just as well as the nine wells, a saving thereby being effected in the neighbourhood of 200,000 dollars in drilling costs alone per 40 acres.

Professor Madgwick thought the oil industry had always been ahead of the market, and until the market was built up full utilization of oil resources could not be brought about. Of present-day losses he thought that connected with gas was undoubtedly the most serious problem. All the points which the author had mentioned were of very vital importance, particularly that there should be central power stations and that it should be absolutely compulsory that no gas should be allowed to go to waste. Another side in regard to waste that had

not yet been discussed sufficiently was with regard to united action in connection with the shutting off of water. In the case of some of the older fields, particularly those in which there were small holdings, the whole of the fields were now waterlogged. If a company owned only a small plot, all the efforts it made in the shutting off of water might be stultified by the inaction of companies owning neighbouring plots. If, however, some general system of water shut-off were adopted the whole field would benefit enormously. In considering how united shut-off of water could be brought about, a still more difficult problem had to be faced even than getting any rational co-operative action taken in regard to offsetting on account of the enormous capital expenditure that would be required. It was quite conceivable that one particular property might have its oil (as well as water) shut off and neighbouring properties might benefit enormously. He presumed therefore that it was only possible to arrive at an equitable arrangement in regard to distribution of production on something like an acreage basis, as the author had suggested in other directions.

Mr. Wm. Ivey desired to deal with four particular subjects, viz. leasing, gas, water, and electricity. Mr. Hudson Hobden had dealt very well with the subject of leasing, but personally he wanted to call attention to another side of the problem. Did anyone present seriously contend that a man owning a property had not a perfect right to do what he liked with it? It was all very well for those who were dealing with the oil question from a scientific point of view to put forward particular propositions, but the man who owned freehold land had himself to consider, and so long as he complied with the laws of the land he did not think that anyone had a right to say that the owner was not entitled to do what he liked with his property. A freeholder generally insisted upon certain conditions being carried out by anyone who desired to lease his land for the purpose of exploiting its oil resources, and one of the conditions which a wise man generally put in the lease was that every time a well was sunk on his neighbour's property the lessee must at once offset it, otherwise he would lose his lease. How would Mr. Hudson Hobden deal with a man like that, and was it not perfectly fair that such a condition should be inserted? The statement had also been made that the small operators ought to get together in their own interests and work their leases on the co-operative principle, i.e. they should combine and pool the production. But what would happen to the little man or the little company owning 20 or 30 acres under those conditions? The moiety which the little man or the small company would have to pay towards the expenses of sinking the first well, particularly if it happened to be a dry hole, would waste the whole of the man's or the company's capital.

Further, he desired to point out to Mr. Hudson Hobden that he did not know yet how exceedingly economical it was to work with electricity. He could mention an oil-field in which there were isolated steam-engines at the head of each well for pumping purposes. In some cases the same remark applied to electricity, a small motor being placed at the head of each well, but in one particular field which had been operated in that manner the 234 wells were finally pumped by ten large motors on the jack system, and as many as 33 wells were saddled on one jack. That was economy *par excellence* and much better than the use of individual motors. In the next place, he desired to ask the author what he would do with the gas that existed on the oil-fields. Supposing a man went wild-catting in a field where nobody had previously had the courage to put down a well and the driller succeeded in bringing in a good well with a burst of from 20,000,000 to 30,000,000 cubic feet of gas a day, what was he to do with that gas ? He was too far away from a city to sell it for commercial purposes. It was an excellent thing if it could only be controlled and brought to where it was required, but how did the author suggest that the fearful waste of gas that occurred in a field where there was no use for it could be avoided, unless the oil engineer bottled the oil up and prevented it coming out of the earth ? If the solution the author had suggested, that it might be turned into power alcohol, was feasible, so much the better, but he imagined that a very expensive plant would be necessary for that purpose, which did not seem to point to an economical use of the gas in oil-fields. Of course where the gas could be used for power purposes every sensible man would use it without thinking twice about the subject. Mr. Hudson Hobden had very wisely suggested that some of the most serious losses that occurred on an oil-field were due to the incursion of water. In California the Government had appointed an inspector to deal with that question, and every oil operator in any field in California had to obey the instructions of that Government official.

Mr. A. Frank Dabell said he thought there was a confusion of ideas in the matter of swabbing, for whilst the author dealt with the subject as a method of production, one of the speakers treated it from the point of view of the driller. They were entirely different operations. Swabbing as a method of production was generally practised by using swab tubes lowered into a well similar to a pumping column. Swabbing from a driller's point of view, or as it was used for cleaning purposes, consisted in using a swab the full diameter of the well-casing. Reviewing the paper itself, from a technical point of view, one might almost deduce that in wells of smaller diameter than 6 inches the author recommended operating a swab in the casing itself. Given a

well with hermetic casing seated just above the oil, the removal of 500 feet of liquid from the surface would induce an inrush of liquid together with fragments of its containing bed, if not the roof itself, and in principle it violated all laws governing successful bailing, unless the well was a very old one with all its drainage channels firmly formed. The advantages of swabbing lay in the fact that the drag or suction upon the oil rock was regulated or neutralized by the head of liquid in the well itself. If the co-called drag of the swab was needed for cleaning purposes, it might be obtained by closing the annular space at the well mouth. He thought also an exaggerated value had been credited to the swab in the matter of removal of solid matters from wells. Under fuel waste the author advised that "well-designed reversing gears enable oil and gas-engines to be utilized." It would be of service to know the principle of such, for all reversing gears he had seen, for either internal combustion or electro-motors, were slow, crude, and costly in maintenance. The author had said that "electrical energy is the ideal power for oil-field purposes other than drilling," and he would like to ask whether the author would modify that, for it was not reconcilable with the scientific bailing of which he was an advocate. Personally he had recently had unlimited electrical power at his disposal and yet had to maintain boiler houses. The electric motor ran at a fixed speed and lacked the flexibility of the steam-engine, which permitted a bailer to be gently lifted off the bottom and drawn through the liquid at an increasing speed. Insignificant as that might appear, it was just such action during the time that a well was being brought into production which made the difference between a caving and a clean well and a large or small radius of drainage for that well. By "clean well" he meant one in which there was no caving but rather a gentle movement of sand, increasing porosity. Electrical power also failed in case of any emergency calling for maximum power. In a swabbing well with the swab lowered to take the minimum load, when a stoppage occurred the rising level immediately added an increasing load to the swab, so that when the bailerman attempted to raise it either the fuse went or the motor burned out, and then during the time of repair it would be found that the level had risen to such an extent that the load was even in excess of the capacity of the rope. Again, when bailing with electric motors, should the bailer be caught in the well the same result occurred with the motor, with the added danger that sand in suspension might deposit, and, by burying the bailer, cause a serious fishing job. When accidents of that sort put wells out of action for a few days only, it might take many months of economy of the electro-motor to compensate for the loss. On the other hand, the steam-engine, when handled by an old operator, could be made to yield a wonderful

momentary excess of nominal power and, moreover, when drawn up, would maintain a steady pull. He did not intend in any way to question the author's just charges of the wasteful nature of the steam-engine, for they were fully justified, but he would point out that the economy of fuel effected by the installation of electric power, whilst most convincing on paper, was open to criticism under skilled hands, for an insignificant decreased output would offset it.

Mr. Albert Millar, referring to the remarks in the paper about the small holdings, pointed out that the evil could be greatly alleviated if laws were passed prohibiting the drilling of a well or wells on plots having an area of less than eight acres with a minimum breadth of, say, 200 feet. On plots of that size it would be possible to place from three to four wells with central steam-generating plant of modern design. If also prospectors were not allowed to place wells closer than 250 feet, one would not then have two or more wells taking out the production which could be accomplished by one. Naturally the distance at which the wells are spaced must be governed by the nature of the sands from which the production is being obtained, which means that each oil-field must be studied individually. Also if prospectors were not allowed to place their wells closer to the boundaries than 90 feet that would to a great extent overcome the evil of offset drilling and thus save much unnecessary expense and waste. In Galicia rules governing sizes of plots and distances between wells had been drawn up and are strictly enforced by the mining authorities. With regard to the wastage of natural gas, the Polish authorities took very strong measures in 1919, when a new gas-field was opened up in West Galicia. The two first wells came into production with several hundred cubic metres per minute at about 80 atmos. pressure. Prospectors at once started an extensive drilling programme, but they were not allowed to drill their wells in before arrangements had been made to pipe the gas away or before the demand for natural gas equalled the supply. That foresight on the part of the authorities saved much wastage. He agreed with the author that swabbing needed perhaps more intelligent direction than any other process, and too much attention could not be given to each individual well. It was quite extraordinary how the wells varied. For instance, one well required intense swabbing, which meant a minimum of ten complete double runs per hour in wells having depths varying from 3800 to 4200 feet, and a stoppage of only a short time caused the production to fall off. In such cases it often took many hours and sometimes days to bring the well back to normal. Other wells, if continuously swabbed, lost their production, but with intermittent working would produce from 5 to 20 tons or more daily. Then there were wells which were very sensitive and must be swabbed

regularly, say five trips per hour, slower or quicker swabbing being attended by loss of production. There were several vital points which must be watched when swabbing if good results were to be obtained. First, when the swab was being lowered in and was reaching the level of the oil in the borehole its speed must be considerably retarded, otherwise much damage could be done to the well by putting back pressure on the oil-producing strata, to say nothing of the damage done to the swabbing line. Secondly, it was very important that the swab should be run out of the casing that was below the casing shoe, so as to allow an unimpeded inflow of the oil into the swabbing casing. One was then certain that the swab was lifting every drop of oil in the hole. Thirdly, the swab should be allowed to remain at rest from thirty to sixty seconds or even more, dependent upon the well, before the upward journey was commenced, and when the upward journey was started the greatest possible speed should be obtained right from the outset, so that the suction effect was as high as possible. There was one very important use to which the swab was put that the author had omitted to mention, and that was for testing out all likely strata encountered during drilling. There were very many cases on record of wells having been drilled into oil-bearing strata without having as much as a show of oil or gas. Intensive swabbing had been tried over periods varying from a few days to as much as six weeks, and in nearly every case a production was drawn in. There were wells which were brought in in that manner which were producing as much as 30 to 50 tons daily, and more, whereas, had the swab not been used, they would have been dry holes. The suction effect of the swab naturally varied with the quantity of gas being produced, but could be anything from 5 to 12 lb. The author was incorrect in stating that it was usual to attach a heavy sinker below the swab. It should be just the opposite, for the reason that it was always advisable to have not more than 10 to 12 ft. below the casing shoe, otherwise it was not possible completely to swab out the well each run, which was most necessary, and if the sinker was below the swab it was not possible. It was usual to place the sinker below the swab only in cases where the casing shoe was damaged or when there happened to be tools or pieces of rod, etc., at the bottom of the borehole, which might possibly trap the swab. It was also advisable to keep the sinkers as light as possible, so that as little useless weight as possible had to be lifted. The author also mentioned that the helical springs were fitted to reduce shock, but that was not all. Their chief function was first to take up the wear of the rubber rings, and secondly to expand the rings to the varying sizes of the casing, such as at joints, etc., and so eliminate the oil leaking past. Where the swab was used for producing, wastage of both oil and gas

could be practically eliminated. It was usual to exhaust all gas from swabbing wells in the following way: the last string of casing which cased the hole from top to bottom was cemented round the top and a seating was made so that when the swabbing string was let in the space between the two strings was hermetically sealed. An outlet was fitted to the larger casing below the derrick floor, and that was connected to the suction line of the exhausting plant. By that means all gas which accumulated behind the casings was taken off and a partial vacuum was formed, so that when the swab started on its upward journey its suction effect was not impaired by the gas finding its way into the swabbing string. Also to the top of the swabbing string was screwed on a flow head, which was connected to the separating tank. That was hermetically sealed and all oil and gas brought to the surface by the swab flowed into that tank, the oil being drained off from the bottom and the gas being taken off by the exhauster plant. If that means was adopted, the wastage was practically nil.

On the motion of the **President,** a hearty vote of thanks was accorded to the author for his interesting paper, and the meeting terminated.

Contribution from Mr. MAY.

A form of loss to which no reference had been made is that caused by fire. Incendiarism, such as occurred in Baku, I think it was in 1904, has resulted in enormous losses; on one occasion I saw at night five fountains all burning at one time together with many derricks and huge open earthen reservoirs of oil.

But more particularly I wish to draw attention to the practice of installing lightning conductors on or near storage tanks and tank farms. It is very questionable whether this practice is not more likely to bring about the very result it is desired to avoid, particularly in the case of light oils.

Careful investigations have resulted in the conclusion having been reached in one instance of which I know, where the ignition of the oil was caused by a spark created by the discharge of electricity between two of the roof plates of a tank, separated at points by rust at the joints.

Another authentic case is the ignition of gases rising from a tank where it was noted that during a storm the gases about 200 ft. above the tank caught fire which travelled down, setting fire to the tank.

It would appear, therefore, that efforts should be made rather to divert lightning by erecting conductors some distance from tanks, than to attract it to what is obviously a danger zone.

Contribution from Mr. ASHWORTH.

In dealing with oil-field emulsions Mr. Thompson has called attention to the distinction which exists between true emulsions and quasi emulsions, and has suggested the possibility of these emulsions occurring naturally. This last point is important, as an admission that emulsions can occur naturally might tend to the operator neglecting to examine thoroughly his method of production and assuming that Nature was responsible instead of some fault in his method. It would be well to examine into the nature of both kinds of emulsion with a view to forming some idea of the possibility of a natural occurrence. Both kinds of emulsion consists of mixtures of oil and water in which the oil predominates. Both must be caused by the simultaneous production of oil and water and an agitation more or less severe causing these to intermingle.

It is difficult to imagine any natural conditions which could cause such an agitation, as the natural movements which have resulted in the concentration of subterranean oil are so slow and gentle that they would be more likely to result in a complete separation. Both simultaneous production and agitation are, however, invariably present when oil is produced from a sand containing both fluids.

The difference between a true emulsion and a quasi emulsion consists merely in the size of the globules of water entrained in the oil. If these globules are above a certain diameter, they can be separated from the oil by mechanical means or forces, the principal of which is gravity. If the globules are smaller than a certain diameter, which has been measured with a fair amount of definiteness, the separation cannot be effected by any mechanical force and resort must be had to chemical, physico-chemical, or electrical means.

The permanence of an emulsion in which the globules are less than a certain diameter has been explained mathematically by the Bureau of Mines in America in connection with oils and in connection with other materials by the authorities on colloids. In fact, a permanent emulsion is a colloidal solution of water in oil. I have just returned from spending a week with Dr. Hermann Plausen, of Hamburg, who is one of the greatest authorities on colloids. He has demonstrated that practically every substance may be obtained in colloidal solution if the particles are of a diameter less than one-thousandth of a millimeter. These colloidal solutions are permanent unless destroyed by heat, acid, or electrical means. The permanence is due to the phenomenon of surface tension. Owing to the fine degree of subdivision the surface bears such a large ratio to the weight that molecular attractions prevent a subsidence by gravity.

He has further demonstrated that without a third substance only very weak colloidal solutions are possible. In order to make a colloidal solution stronger than about one and a half per cent it is necessary to add a third substance which he terms a dispersator. This third substance must be selected so as to be complementary to the substance to be colloidized. With this addition, it is possible to obtain concentration of colloidal solution of 25 to 35 per cent strength.

I think that this is the explanation of the fact mentioned by Mr. Thompson that certain salts aided the formation of oil-field emulsions. In refining oils many of us have experienced the difficulty of avoiding emulsions. With certain oils they are very apt to appear when neutralization is being performed after acid treatment. The emulsions do not appear when the acid treatment is being made, for the reason that, as mentioned above, acid destroys the colloidal condition. In this case, emulsions are avoided by adopting very gentle agitation. As soon as agitation exceeds a certain amount the whole of the contents of the agitator will often pass into a permanent emulsion in a few moments.

This effect of the velocity of agitation has also been found by Dr. Plausen in the operation of his colloid mill. He found that below certain velocities no colloids were formed, but above these velocities colloids were freely obtained.

It may be fairly assumed that all oil-field emulsions are formed by agitation of a mixture of water and oil, and that the question as to whether quasi or true emulsions are formed depends on the velocity of agitation.

In considering the character of these emulsions in connection with the possibility of natural occurrence it is most important to examine their behaviour in passing through a porous material like an oil sand. When we try to filter a quasi emulsion we find that a complete separation of the oil and water is accomplished. It is an ordinary laboratory method of freeing a sample of oil from water to filter the mixture. The two fluids will not pass through the filter together. When we try to filter a true emulsion we find that it is almost impossible to filter it at all under ordinary pressures. A colloidal solution of water in cylinder oil is as thick as cup grease. Dr. Plausen has invented what he terms an ultra filter, and claims that when colloidal solutions are filtered through this at enormous pressures the colloidal solution is destroyed and the medium filters free from the suspended colloids.

Even if we admit the possibility of emulsions occurring naturally, how can these pass into the borehole except by filtration through the

pores of the oil sand? And if such a filtration occurs does not all our experience show that the emulsion would be destroyed during filtration? I submit that every emulsion met with in production has been caused during the process of production, although we may not be able to locate the place in our equipment where it is produced.

When oil-field emulsions are met with the first thing to be done is to ascertain where they are found and then to make such alteration to the plant at this point as will tend to reduce the agitation. In the recently discovered Eldorado field in Arkansas the wells produced large quantities of gas and water as well as oil, and much trouble was first experienced from emulsions. At length it was found that these were formed at the points where the fluids entered the choker pipes. The trouble was overcome almost entirely by inserting some lengths of ten-inch casing between the casing head and this point. This ten-inch casing acted as a settling receptacle in which the water settled out and was drawn off separately. The oil was then obtained free from emulsion.

In pumping wells emulsions are often formed when the working-barrel cups are faulty, as in the pumping stroke the oil is forced at a high velocity through the leaky cups. A replacement of the faulty cups will generally overcome the difficulty.

Prevention is better than cure, and no effort should be spared to locate the cause of the trouble. Where all efforts fail, one or other of the methods enumerated by Mr. Thompson must be adopted in order to save waste. The selection of the method will depend on whether the emulsion is a true emulsion or a quasi emulsion. The methods of curing a quasi emulsion are generally easier and cheaper to install than those required by a true emulsion. If large quantities have to be dealt with any method but the simplest heating in the storage tank will require considerable plant installed at a large expense. Even heating in the storage is accompanied by waste in the case of a light oil. The operator is generally faced with the difficulty of knowing what expense in plant is justified, as although he knows what amount of emulsified oil he has on hand this is generally not enough to justify a large installation, and he has no means of knowing what amount of emulsified oil he will have to deal with in the future. Hence, although many ways have proved successful in curing emulsions, the more scientific and less wasteful ways are only open to those who are operating on a big scale.

Contribution from Mr. IBBETT.

Mr. Beeby Thompson is entitled to the gratitude of all oil men by his handling of the subject of oil-field waste. The subject is such

an extensive one and covers so many phases of waste, that one paper alone cannot fully cover all points.

A great deal of watertight-compartment atmosphere has prevailed in the past in regard to geological work, whereas so much might have been gained by an exchange of information and maps that great progress and economies would have resulted. This difficulty of co-operation has been almost confined to English companies. In U.S.A. official records have always been open to all and the spirit of co-operation at least always manifested in regard to geological information.

Opportunities exist in almost every developed field, where co-operative power supply would have saved much money. Over-drilling has been an offence committed in almost every known field; the remedy is simple but needs technical advice and management.

Many oil companies, especially the younger ones, are governed by a Board of Directors having no intimate knowledge of the oil business. This has been the greatest trouble and the cause of the greatest amount of waste; the oil business calls for the greatest skill, perseverance, and experience, and only those men who have proved themselves capable should be sent to operate oil-fields.

Mr. Beeby Thompson has very ably dealt with productive waste, power waste, etc., and there can be no doubt that economies and general stoppage of waste can be effected on every field, but the first essentials would appear to be: (1) First-class control and supervision, and (2) the spirit of co-operation.

Contribution from Mr. J. KEWLEY.

I regret that time did not permit of my taking part in the discussion of Mr. Beeby Thompson's paper last Tuesday evening. I should like, however, to make a few remarks.

I think the question of losses by evaporation and possibly also from leakage from storage tanks, not only of crude oil, but also of intermediate products and refined products, is one to which serious attention should be given. In an article by J. H. Wiggins in *Petroleum Age* for July, 1920, figures are quoted stating that the loss in storage on leases in the Mid-Continent field are of the order of 122 million gallons per year, a quantity which is equivalent to about 3 per cent of the gasoline production of the U.S.A. in 1920. Conditions of storage on leases, of course, are usually by no means of the best. Even in storage tanks in this country, under temperate conditions, the losses by evaporation of light benzine may be very considerable.

The writer had occasion once to store aviation spirit in a tank built for liquid fuel. The tank was fitted with a steel roof, but this was not

gas-tight and had an opening for the passage of the swing pipe and steel rope. The losses in the summer in this particular tank amounted to nearly 1 per cent per month. This is, however, an extreme case.

Observations carried out on storage of light benzine in steel-roofed tanks, painted white in hot climates, with a mean temperature of 26° C. showed a loss of nearly 1 per cent per month. Expressed in terms of area of evaporation surface of the tank, this amounted to 2 kilogrammes per square metre per day.

The losses of benzine vapours connected with the discharge of tank steamers must also be very considerable. There is no doubt that a good deal could be done to remedy this state of affairs by the erection of gas absorbing plants.

Wherever possible storage tanks should be painted white. Some experiments carried out on tanks painted black and others painted white used for the storage of a heavy crude oil showed that whereas the loss in the case of the black tanks amounted to ·594 per cent in a certain period, the loss of the same oil stored in the white tanks, under the same conditions, amounted to only ·278 per cent.

It was suggested in the course of the discussion that alcohol might be made from petroleum gases. This has indeed already been done. A quantity of propyl alcohol is manufactured from the propylene evolved from certain cracking stills in the U.S.A. by a process similar to that devised by Bury for the manufacture of alcohol from coal gas.

Contribution from Mr. MCMULLEN.

Mr. McMullen wrote to ask if information could be given on the following points :—

Screen Pipe.—Does Mr. Beeby Thompson condemn unreservedly the use of screen pipe in all loose sands ?

Emulsions.—Has he any information as to the success or otherwise of the use of soap solution or the soap-like salts of sulphanated oils for breaking emulsions ? If these can be successfully used it would appear that the capital expenditure for plant would be much less than that for centrifugal or electrical process—the running costs would probably also be smaller.

Gasoline Recovery from Natural Gas.—If he can give any information as to the first cost and particularly the life of the " activated charcoal " used in the " Burrell " process of gasoline recovery ?

Gas.—If the chlorination of natural gas for the production of chloroform the carbon tetrachloride, etc., may not prove a possible use for some portion of the natural gas at present going to waste ? The

market, I take it, for these products would not at present be very large, but if a cheaper supply were established it might greatly expand.

I would like to emphasize the necessity for keeping complete records, logs, history, and production of every well. Without these complete records it is at least difficult and sometimes impossible to diagnose correctly, much less successfully treat cases of what may perhaps be called underground waste. For example, to secure and analyse a sample of the water from each water stores is usually not expensive or difficult *when a well is being drilled*. Lack of this information may turn what might have been an inexpensive repair job into a series of costly experiments.

Mr. Beeby Thompson wrote, in reply, that Mr. Ivey had made some very interesting remarks in regard to the leasing question, the difficulties surrounding which are very obvious. Small landowners often lost their oil rights because legislation had been introduced disallowing drilling on an area less than a fixed size or within a defined distance from another well, so that unless they could effect an amalgamation with an adjoining landowner they automatically lost the rights of which Mr. Ivey desired small people should not be deprived. With regard to the question of pooling, usually the small landholder never got a reasonable chance, because unless he disposed of his rights on any terms offered, operations on neighbouring land would drain his property and render it valueless. In most cases he was practically compelled by circumstances to pool his land.

He was agreed with all Mr. Dabell had said about steam, which was the most flexible and reliable form of power that could be used in oil-field work; but unfortunately under oil-field conditions it was the most wasteful and expensive. Whether they liked it or not, oil-field engineers would have to change their minds and put up with electrical power, although drillers did not like it, and there were difficulties and objections that rendered it unpopular for certain purposes. He did not think Mr. Dabell was correct in what he had said about swabbing. Surely Mr. Dabell did not mean to infer by his remarks that bailing deep wells incurred a violent jerk on the bailer. It was impossible to get the sudden piston-like movement that he referred to at the bottom of a well when there were 2000 ft. of $\frac{3}{4}$-inch rope which stretched, a belt that slipped on the pulley, and probably also a friction clutch on the drum which would slide. Personally he only advised swabbing when no other method could be employed, but he did emphatically insist that in a number of oil-fields at present operated by other methods much higher yields could be obtained by swabbing than by the process at present adopted. That was particularly the case where the rocks were sealed with wax which had to be abstracted or where the rock-

pores were plugged with salts of various kinds due to the concentration of fluids by the evolution of gas. There was no other process known at present which would remove such obstructions as readily as swabbing. In the cases mentioned in the paper, all other methods had failed, and were destined to fail in effecting the wonderful improvements described.

The remarks about swabbing had been particularly interesting. Mr. Millar was the swabber to whom he had referred when inviting discussion. Mr. Millar was an authority with recent experience in swabbing, but personally he did not understand his attitude in condemning the lower sinker. When he was in Galicia some years ago he was assured by one of the leading operators there that before they adopted the lower sinker their swabbing rubbers had to be constantly renewed. When they used the lower sinker to keep the swab vertical it made all the difference in the world. There must naturally be a sufficient weight to carry the swab down to the bottom of the hole, but he failed to see any advantage in placing this weight above the swab instead of below.

Mr. Kewley's observations closely conform with similar tests made by the writer. The losses by evaporation are exceedingly great both in production and during subsequent storage, especially in tropical countries or during summer temperature in temperate climates. A closed circuit between the wells and the storage effects a great improvement, but may necessitate a slight back pressure on the wells that often diminishes the immediate, if not the ultimate, yield. In California the density of recovered crude oils has been materially lightened by the use of the McLaughlin separator, and observations of density of oils produced by various methods of extraction indicate the importance of following up losses of this character. Oil tanks may be arranged to "breathe" through an absorption apparatus where atmospheric and other conditions tend to create high losses.

An interesting evaporation curve can be produced by plotting percentage losses against time. It will be found that in hot countries the main losses are sustained within a few hours following the midday heat.

In reply to Mr. Wallace McMullen, the writer does not disfavour the discriminate use of screens, but they must be used with the greatest caution. Where the sands are very fine and not of mixed grade the admission of oil will be too much restricted to obtain profitable yields, and where streaks of clay or shale cut up the sand body fine screens often become firmly sealed by clay. In one instance where a number of screened wells ceased to yield more than a few barrels daily, the writer offered to accept any well the operator might select to demonstrate

that the oil was not exhausted and that plugged screens were responsible for the low yields. A well was chosen at random and immediately the screen was removed the well flowed and a good yield resulted. In certain types of ground large quantities of sand must be removed if fair and sustained productions are to be assured; and in compact sands the equivalent of sumps and channels of low resistance are artificially created by the use of powerful explosives.

The writer has no knowledge of the use of soap solutions for breaking down emulsions. Usually soap-like substances are apparently associated with the formation of emulsions and would encourage their formation. As explained by Mr. Ashworth, emulsions are often formed when agitating oils with sodium hydrate in refineries.

Activated charcoal has been more or less a preserved industry up to date, but there is reason to believe that this will not remain so as other forms than nut charcoal appear applicable. It is said that the properties of activated charcoal do not diminish with use.

The chlorination of natural gas on any important scale would appear to cause a glut of products for which no immediate use on such a scale is to be found.

It is impossible to overrate the importance of keeping accurate and comprehensive logs and records of all wells from their birth to their extinction. Every day one feels more and more the losses sustained by science in failure to record properly the history of past developments.

Mr. A. A. Ashworth's contribution is valuable in defining the conditions combining to produce quasi and true emulsions. His reference to the Eldorado cases where emulsions were formed outside the wells confirms the Mexican instance quoted. The bulk of evidence is certainly in favour of formation in the wells rather than occurrence in the earth—a fact that laboratory work tends to confirm. The presence of some third agent besides water and oil certainly favours the formation of emulsions, and colloidal clay would appear to be a frequent contributor.

The meeting then terminated.

The Sixtieth General Meeting of the Institution of Petroleum Technologists was held at the Royal Society of Arts, John Street, Adelphi, W.C., on Tuesday evening, 13th December, 1921, Professor J. S. S. Brame, President, occupying the Chair.

The Members of Council present were Herbert Barringer, Dr. A. E. Dunstan, Arthur W. Eastlake, James Kewley, Dr. W. R. Ormandy.

The following gentlemen were elected at the last Election Committee :—

As *Members* :—P. A. Ashmead-Bartlett, J. A. Child (transferred from Associate Membership), R. H. Findlater, W. E. Gooday (transferred from Associate Membership), G. W. Halse (transferred from Associate Membership), G. Johnston, C. H. Liedbeck, G. J. Savage (transferred from Associate Membership), H. B. Thompson, L. J. Wilmoth.

As *Associate Members* :—P. B. M. Furnell, R. N. Rogers, A. D. Whitman.

As *Students* :—W. E. Aylwin, R. L. C. Bleeck, F. E. J. Foxall-Smedley, J. A. Green, H. R. Higgins, C. V. Hill, D. P. Rees, S. R. Say, K. Sadler, W. E. R. Westmoreland.

As *Associate* :—Lieut.-Col. L. Fortescue-Wells.

The President, at the opening of the meeting, said at the last meeting of the Institution a very instructive and interesting paper was read by Mr. Beeby Thompson on "Oil-field Losses," which evoked a very valuable discussion. As a direct result of Mr. Thompson's paper and the big problems which were involved, Mr. Dabell was inspired with the idea of giving a short paper to the Institution which supplemented and commented on some of the matters dealt with by Mr. Beeby Thompson, with a view to promoting a useful discussion, and he hoped the technical members and visitors of the Institution who were conversant with details of field operations would contribute to the discussion, as the value of the papers read before the Institution very largely depended on their discussion.

The following paper was then read :—

Better Production Methods.

By A. Frank Dabell, M.I.Mech.E.

Huntley, in his paper upon "Possible Causes of the Decline of Oil-wells," declares that :—

> "*The reason for the decline of oil-wells may be grouped in two classes—those due to natural causes and those due to poor management.*"

Natural causes are, presumably, those which are reflected in the normal curve of well production under any given system of development now in practice. It will be appreciated, however, that the dominant factor in the correct determination of any natural rate of

decline is the area and effectiveness of drainage of any single well. This is a factor which varies in every field, and in all cases it is dependent upon the efficiency of the technical policy adopted for bringing fields and wells into production.

It was shown in the last paper, read by Mr. Beeby Thompson, that natural decline may be temporarily arrested, for example, by the use of an exhauster, and one stage further by the use of compressed air, whilst a further renewal of life may be given the well by washing the oil rock with water or solvents. It is therefore evident that natural decline, as it is usually recorded, is susceptible to arrest and control by the volition and skill of the operator. In other words, the declining output of a well can be governed very largely by technical practice, and the division by Huntley, unless interpreted in this sense, cannot be maintained.

Under present working methods a production diagram showing a steady rise for some few weeks, an horizontal line for some few months, and a falling and flattening line for a few years is described as "an excellent graph." Under this system wells are now declared exhausted and are abandoned for commercial reasons, whilst, in fact, a minimum of 50 per cent and a possible 90 per cent of oil remains in the sand.

The truth is, that, although the natural forces in the oil-sand are sufficient to expel only a very small portion of the oil, much of the remaining oil within the area embraced is capable of recovery if new forces are applied. A very different graph would then be obtained. To obtain better results calls not only for extension of the area of drainage of productive wells but also for the practice of better methods of recovery from the sand, and this latter object demands, in the first place, an increased attention to the act of bringing new wells into production.

It is a common fallacy to suppose that a well having been drilled to oil it is then merely a matter of raising the liquid to bring the well efficiently into production. Of all field operations the bringing of wells into production deserves the greatest amount of care and skill, for it is during this period that the area embraced for drainage is determined. Drainage is dependent upon the formation of channels radiating from the well, and the distance from the bore of the vanishing points of the smallest of these channel-veins determines the area of drainage.

Ideal conditions governing perfect production, as existent in the limestone formations of Mexico, are described by Messrs. Huntley as follows :—

> "*The limestone is not naturally porous but has been channelled by underground water, apparently associated with igneous intrusions of the late Tertiary Age which are common in the field.*

> "*Such cavities and channels are filled with oil on the crests of some of the main folds in the region, and, as would be expected, are filled with water down the dip on the flanks of the fold and in the basins,*" to which must be added the fact that most Mexican wells flow continuously under their own pressure until exhaustion.

Whilst these conditions are unique they are interesting from the point of view of migration of oil and water, and, where such happy conditions do not exist, they may be taken as deserving reproduction. Toward obtaining such results in average formations, each cubic foot of gas should be made to perform its work in expelling the liquid, eroding the rock, and forming canals. The incoming oil should steadily carry with it in suspension that quantity of eroded sand that can be removed with the liquid. When sand enters at a faster rate than it can be removed the rate of exhaustion should be reduced, and, conversely, the rate of exhaustion increased when no sand be in evidence. In loose sand the purpose should be to create areas, which, if not channelled, are regions of reduced density.

In practice these conditions are often reversed by, e.g. the sudden closing in of fountain wells, or, by two violent removal of liquid from new wells, putting into motion a volume of sand which, when arrested, chokes existing veins and prevent the formation of new ones. Further removal of this sand entails in time the removal of the containing bed. This theoretically is immaterial, but without the skeleton or some part of the containing bed being left in place the barren covering strata fall, and effect actual choking.

Under the best practice a time arrives when incoming sand is no longer in evidence, and whilst the oil output may remain steady for a short period, decline quickly follows; provided, however, that this decline be regular, effort is rarely made to arrest it until production, dependent on mere gravitational seepage, falls below the level at which it can be economically continued.

It has been shown, however, that this decline may be arrested, yet the methods are being but little practised. The preliminary effort may be by the application of an exhauster to the producing well, but whilst the reduction of atmospheric pressure upon the surface of the liquid will assuredly arrest decline and show profitable results, it prejudices the practice of better methods. Reduced pressure is apt to result in the raising of the viscosity of oil in the vicinity of a producing well by favouring the volatilization of the lighter fractions. This in turn offers opposition to the migration of the natural oil. This objection would not apply in cases where application of the exhauster would establish

effective communication with another well, as sucking air through the sand would be more likely to stimulate the contained oil than otherwise. In lieu of applying the exhauster to a producing well the practice of introducting a propellant in distant wells has been demonstrated as capable of winning a larger area for production purposes, and of ensuring a better recovery from the sand. In determining the best propulsive medium the choice lies between gas or liquid, and data upon the relative advantages of each have been compiled by Dr. J. C. Lewis and published by the U.S. Bureau of Mines.

From these data it appears that water has been used with success in wells at Bradford, Pennsylvania, and that air has given equally good or even better results over a wider though still restricted area in the United States.

Air.

In the application of air, of which Messrs. Smith and Dunn were the pioneers, air is forced into the producing sands under varying pressures through some of the wells on a property, which are called "air wells," the oil being pumped from the other wells in the usual way.

Where the air has a tendency to blow straight through sand from which most of the oil has been removed the outlet at the producing well is restricted, compelling the air to spread out and charge the more distant oil. The principles upon which the compressed air moves the oil through the sand are first, by direct pressure; second, by the carriage of vapours; and third, by the air going into solution in the oil and ultimately expanding near the producing well. (It may be remarked in passing that this latter process might in time tend to create inductive currents which would further accentuate migration.)

The essential equipment in an air well consists of hermetic tubing to the oil-sand arranged in such a way as to prevent the air having access to any other formations, and an air compressor, of any efficient type, the size of which is dependent upon the area of the property being dealt with, and the density of the oil-sand.

It has been noted that the pressures used have little relation to the depth of the wells, but are intimately related to the character of the oil-sands, coarse, porous sands taking the lowest pressures and dense or closely grained sand the highest; that there is a marked tendency for the gas to slip by the oil without expending much energy in moving it; that an average of about 10,000 cubic feet of free air per day is used for each well.

Reports go to prove that the system has been successful in 80 per cent of the cases where used, in 32 of which the output has been increased three and one half times and, after three years, shows no sign

of diminution. The alternative propellant for bringing oil within reach of the productive well is water, passed down distant wells into the oil-sand and forcing ahead of it the oil-content.

There is a serious prejudice against pumping water into productive strata, but in Nature a body of water under moderate pressure behind the oil does, in its so-called encroachment, move the oil toward the wells, leaving the least possible amount of oil in the rock. Carll, Huntley, Johnson, and other Americans who have studied the matter declare that displacement of oil with water, whilst sound in theory, is difficult in application by reason of the uncertainty of the direction of movement, where reliable data as to underground conditions are lacking. Putting water into the sand calls for but little effort where water is available, and at Bradford (previously referred to) it has been practised with success for twenty years. Dr. Lewis, through the U.S. Bureau of Mines publications, has fully reported upon this system as there applied.

The results of his study go to prove that the water movement being governed by porosity of the sand, degree of oil saturation, presence of gas and hydrostatic head, its rate of travel did not exceed ten feet per month, although in other fields a rate of 200 feet per month has been observed. Movement tended toward and followed paths of low density often in opposition to gravitational effort, and some of the propelled oil was often trapped by irregularities in the top of the oil-sand. The Bradford sand is described by Ashburner as being of ordinary beach sand coarseness, compact yet loosely cemented and lying almost horizontal.

Experiments made by passing water through partly drained sand reveal a tendency on the part of the water to surround bodies of oil. On the whole, evidence that water, oil or gas invariably tend to move toward the area of low resistance emphasizes the necessity for obtaining the largest possible drainage area for each unit when bringing wells into production.

In the choice of a propellant for the further extension of this area, air offers primarily the greatest advantages. This arises from the fact that it can do no harm to the oil-sands, for soon after cessation of pumping the air content attains a state of equilibrium and ceases to have any active effect.

Further, study of the air movement will supply general data as to underground conditions and so be of value in indicating the possibility of the use of water and its probable directional tendencies. In certain fields data are already available. For instance, in the Maikop district Sara has established that the oil lies in coarse sand and gravel, filling a subterranean river bed. This old river lying upon foraminiferal marl

with its changing line of direction and sectional lenticular form is clearly defined at the several points where it has been developed.

It will be a reflection upon modern methods if the intervening plots, withheld from exploitation, be drilled upon and separately developed until decline from accepted natural causes lead to their abandonment, for there would appear to be no technical reasons prohibiting practice of the methods outlined. It is by such means that a more perfect production diagram could be obtained, which in turn would connote a more successful development and exhaustion of the oil containing rock.

In conclusion, there is good reason to anticipate that application of the principles advocated may in time lead to recovery of oil from sources which are inaccessible to the drill.

DISCUSSION.

Dr. Ormandy, in opening the discussion, said that he would venture to point out a possibility in connection with the subject which arose out of a paper recently read by Dr. Fyleman. If water was to be used to displace oil which lay in either a fine or coarse sand, the main difficulty was that the water tended to take short cuts, because it had an inherent tendency not to wet a particle which was already wet with the oil film. Fyleman pointed out that, in dealing with the tar sands of Athabasca, whereas it was very difficult to remove even a considerable proportion of the oil by means of hot water, if the water were pure, it was quite possible to remove very large percentages, almost the whole in fact, if the water were made slightly alkaline, owing to the fact that the addition of alkali reduced the surface tension and enabled the water, thus made alkaline, to commence wetting the sand particles, and so gradually to creep forward, pushing the oil in front of it. He was once present when it was desired to use a great heap of broken granite for making a tar macadam road, and it was desired to wet the stuff with tar before spreading it on the road. The road makers were very much troubled by the fact that the tar would not spread. They poured it on some of the stones and it ran over the surface. An Irish labourer who was present said that he could make it run on the stones, and on being asked how he would do it he said he would get a quart can of cresote oil, which he would pour on to the stones, which would drive the water out of the stones so that by putting the tar on the top they were enabled to go on with the job without waiting days for the stones otherwise to get dry.

Mr. Barringer thought it was fairly well established that the use of compressed air was useful up to the extent of 80 per cent mentioned

by the author, but the part of the paper which appealed to his imagination was the last sentence, in which the author mentioned that there might be a possibility of recovering oil by the use of compressed air where it was impossible to put down a bore hole in that particular position. That he thought opened up infinite possibilities which should be very closely examined and investigated. Another point in connection with the use of compressed air was that where holes were in fairly close proximity the introduction of compressed air in one bore hole might possibly drive the oil to another. One would expect it to do so, in which case, although oil was not recovered through that particular bore hole, it might be recovered from bore holes in the vicinity to which the oil has been driven by the compressed air.

Mr. Ashmead-Bartlett thought that before compressed air or other artificial aids were used much more use might be made of Nature's propellant, the natural gas, by locating wells away from the crest of the fold, so that the gas, instead of to a certain extent preceding the oil and sucking it out, would act more as a piston and drive the oil to the bore hole, and so be conserved underground for a much longer time. He imagined that the case of wells blowing off gas for a long time and then turning to oil was within the experience of most members of the Institution. It did not require any stretch of the imagination to picture the great loss in propellant power as represented by that escape of gas, whereas if those wells had been drilled on the flanks that gas would have been available as a propellant before it escaped into the air.

Dr. Wade said that, while he was in general agreement with the author, it had been suggested by one speaker that bores should be made some distance from the crest of the anticline to avoid the greatest gas pressures and in order that such pressures may be utilized in expelling oil, but it did not always follow that the greatest gas pressure would be struck on the crest of the anticline. There were such conditions met with as lenticular sands which may trap the gases well down on the flanks of the anticline. In a case of that kind it was necessary to find where the gas was before starting on some very definite scheme of operations as had been suggested. If the sands were in lenticules it was necessary first of all to find out how the sands lay.

Mr. Dabell said that in practice both had occurred. Separate grains of the sand had been found to hold oil of their own, and also patches of saturated sand forming islands had been found.

Dr. Wade subsequently wrote :—

As an additional contribution to the discussion may I suggest that oil-field geologists and engineers interested in the lines of flow of underground water, whether it be water native to the strata or introduced

by the engineer, may find some useful information and valuable data in the reports of the Committee on underground waters, formed by the Yorkshire Geologists' and Field Naturalists' Association, published in the *Proceedings* of that Association. Personally I have used some of their methods and have obtained very interesting and sometimes surprising results, especially from the introduction of fluorescein into well water.

Mr. McQueen said that it seemed to him that the use of air must have the effect of volutilizing some of the lighter hydrocarbons from the crude, which would render the viscosity of the oil considerably greater and would thus have the effect of retarding the flow.

Mr. Ibbett said the question of the use of air brought to his mind the possibility of using air in other directions, he referred particularly to the air lift. The ideal conditions were those referred to by Mr. Gordon Pitt, and the difficulty was that they were seldom met with, each well had an individuality entirely its own and each field likewise. Reference had been made to drilling on the crest, but he thought all petroleum technologists had learned their lesson concerning locating bore holes on the top of new structure, that had not been drilled before, for the reason that they tried always to get away from the gas pressure. One of the previous speakers had mentioned that it was almost impossible to find those ideal conditions anywhere outside of Oklahoma or Texas or Mexico, and this was quite true. A great amount of drilling had been done in Trinidad in the last six or seven years, and unfortunately gushers had been encountered. As an instance of how little control really existed, two wells had been drilled side by side, the second one presumably down the flank, the sand being hit at a much higher depth, confirmed by the fact that a much stronger gas pressure had been met. Presumably the reason for that was that below the first well, and still further down the flank, the second well had been linked on a thinning out of a lens which had its greater capacity still further down the flank, and that second well had tapped a high spur in the flexure which the first well had not done, so that really there could be no control in such matters except in a general sense. With regard to the question of the drilling in of wells, he quite agreed with Mr. Gordon Pitt that the ordinary driller should never be left to himself when he drilled in a well, but, so far as his experience was concerned, that was never done. He had often read the famous paper that had been published on the use of mud-laden fluid. If a rotary was put on and everything possible was done with what the companies would provide in the way of machinery and materials, every possible precaution being taken to guard against the well "getting away," then all possible had been done, nevertheless in ninety-nine cases out of a

hundred the well "got away." If the engineers were able to keep the well, to mud it up, to get the drill pipe out, they were exceedingly lucky. At the present moment he knew of a well in Trinidad the drilling in of which he personally superintended for one and a half months. The first time it was decided to drill it with a 4-inch drill pipe and it blew out. Very little oil, however, was obtained, because mud went down and killed the oil, but every second day the mud would be blown out of the hole. Finally it was then decided to put in a string of 8¼ casing, which was cemented. An extra heavy blow-out preventer was put on, the derrick was strengthened and a whole string of new 6 inch extra heavy drill pipe brought and put in. At the present time that 6 inch pipe went up and down about 4 feet every fifteen minutes, until the chains that held it were so tight that it could not go any farther. It had been decided that it was impossible to proceed any further with that particular well and that another well should be located in another place, an attempt being made to relieve the gas and oil pressure and then to go back to the original well. With regard to the question of the use of an alkaline solution, there was generally quite enough salt in wells already. He did not think that any salt water or any emulsion would have an affinity for such alkaline solutions as might be put down. Putting water down wells was asking for trouble. Some years ago he visited some of the old fields in the States where water was being used, and, while one man (who put it down) would admit that a certain amount of good was being obtained from its use, a man on another lease would complain most bitterly about it, saying that he never had any water in his well until the owner of the adjoining well put water down. The use of air in connection with wells was also investigated at the same time. The first objection he had with regard to putting air down wells was that aeration would occur; enough trouble was experienced in getting all the lighter hydrocarbons when the oil got to the tank from the time it left the bottom, and yet it was suggested that the very thing should be done that oil engineers were striving all their lives not to do, namely, to put air down and cause aeration and loss of light constituents. On the other hand, with regard to using compressed air for the purpose of suction and lift, particularly with regard to straight air lift, he thought much less risk was run from aeration. The area over which the use of air was spread with air lift was a very confined one, and confined to the base of the actual well which was being operated. A great deal of work had been done by American supervisors, particularly in California, in developing the proper lines of drainage in the field, having due regard first to the gravity of the oil, second, to the thickness of the sand which was being operated in, third, the liability of the cap falling in, and fourth, the porosity of the sand

from which the oil came. Another point which he desired to mention was that of over-drilling, to which due regard must be paid. It was no good drilling two wells to five acres in a field where there was coarse open sand; one well in ten acres would probably be sufficient. It was necessary that oil company administrators should have brought home to them the necessity for the employment of scientific and practical methods in the carrying out of field operations. There had always been in the past a terrible lack of co-ordination between the geological staff and the engineering staff. The engineer on the field was in the dark unless he was working in very close co-operation from day to day with the geologist; the value of one man's work was absolutely neutralized if he was unacquainted with the work being done by his colleagues. He thought great credit was due to the author for tackling the question under discussion.

Mr. Anfilogoff said from his recollection of some of the oil-fields, including the mid-Continental fields in the States, and especially the Texas fields and the oil-field of Spindletop, where the derricks were situated within a yard or two of each other, he had wondered whether the first man who suggested putting water or air down one well, in order to get the oil into the other, was not an out-of-work lawyer. From the point of view of the people who had to do the distilling, he desired to say that refineries in general would be overjoyed at Dr. Ormandy's suggestion of a solution of soda in water being pumped into oil wells, or if air was pumped down at the possible aeration of the oil. He knew from bitter personal experience that, in the case of crude oil where no water or air had been used, even after all the settling at the wells, after being pumped up from the tanks to the ships, and after settling in the ships, a large amount of sludge, mud, and all sorts of soapstone solutions and emulsions were still found and had to be dealt with in the crude oil. He wondered whether Dr. Ormandy had ever been faced with the problem of attempting to break down one of those emulsions. He was afraid, from the point of view of the refiner, that if air or water or caustic or carbonate of soda were pumped down into one well and it passed through the various channels till it reached the other well, and if it became possible to get this into the bailer or pump when pumping the oil to the storage tank, the churning up it would receive in the pump would cause an emulsion, which would add to the refiner's troubles.

Mr. J. Kewley said that there seemed to be a difference of opinion with regard to emulsification and aeration of the oil. It seemed to him that in any particular case a decision must be made upon its merits. The question to be considered was whether it was more profitable to produce extra oil from the wells at the expense of emulsifying it. He

knew that it was difficult to distil or to treat such emulsions, but it could be done, and, although that in itself must be a costly operation, the value of the extra oil obtained might more than balance that cost. The same applied exactly to the question of aeration. Some light hydrocarbons might certainly be lost by aerating the oil, but if a bigger output were obtained from the wells, the loss of light hydrocarbons would surely be a matter of minor import.

Mr. Penny said that there was one point on which he differed from the author, namely, in the statement made: "Under this system wells are now declared exhausted and are abandoned for commercial reasons whilst, in fact, a minimum of 50 per cent and a possible 90 per cent of oil remains in the sand." Personally he thought that was a very debatable statement indeed. He had had the experience of drilling on a field in Russia in which a heavy gusher was brought in which commercially exhausted the sands. After drilling well after well on that particular plot, although there were 20, 30, or 40 feet of oil-sands, they were entirely exhausted. If from 50 to 90 per cent of the oil was supposed to be left in the sands, it should certainly have shown in the sands which were being brought up from the new wells which were being drilled into the exhausted territory. He thought it was a mistake to assume that there was from 50 to 90 per cent of oil left in what was generally supposed to be commercially exhausted territory which had not been treated by any of the special methods mentioned.

Mr. Penny wrote further:—

The question as to what quantity of oil remains unrecoverable in the sands under present working methods, and of the means to be applied for the recovery of a portion or the bulk of this residuum is of such importance that the information given in the present and the preceding (Mr. A. Beeby Thompson's) paper cannot fail to have interested most of those who heard them read.

The value of these special-recovery methods is in direct proportion to the amount of oil remaining in the rock unrecoverable by ordinary means, and this fact makes the determination of the amount of that residuum a matter of the first importance.

The variation in the estimates of percentage of oil remaining unrecoverable is striking, and it is to call attention to this fact that the present note is written.

That there should be great variations in the figures for different localities where formations, viscosity, etc., are unequal is natural, but, apart from this, opinions as to the general average figure of the unrecoverable oil vary considerably.

In Mr. Dabell's paper the figures—based on bulletins of A.I. of M.E.

—of a minimum 50 per cent and a possible 90 per cent residuum are mentioned, and these high estimates are probably accepted by many in America and elsewhere.

Against these figures can be set those of Washburne, who "assumes that from 60 to 75 per cent of the oil is extractable by ordinary producing methods" ("Estimation of Oil Reserves," *Bull. A.I. of M.E.*, Feb., 1915). This would give an unrecovered residuum of 25 to 40 per cent only.

Again, Johnson and Huntley write: "Methods of extraction are so inefficient that from 20 to 75 per cent of the original oil content remains in the rock after the wells are abandoned."

Basing his opinion on the forementioned authorities, the writer considers that he is justified in expressing the opinion that the average unrecoverable residuum has a minimum figure *nearer* 5 per cent than 50 per cent, say a mean figure of 25 per cent. (It will be observed that 25 per cent is nearer to 5 per cent than to 50 per cent.)

According to the experiences of some of those engaged in drilling in the Maikop Field, Russia, in 1910, and later on plots commercially exhausted by neighbours' exploitation and gushers, it would appear that, given the conditions of a fine, loose sand and a light oil (·833), the unobtainable residuum will be even below the lower limits given by both Washburne and Huntley. This is borne out by a production obtained there exceeding "314 tons per acre-foot or 30·4 per cent by volume" (A. Beeby Thompson's *Oil-field Development*), an extraction which, even assuming a porosity as high as Hager's highest limit (35 per cent), gives what may fairly be assumed to represent an almost complete recovery of all the original oil content of the rock, the more so seeing that production is mentioned as still continuing at the time the 30·4 per cent by volume figure was reached.

The writer recollects that these 314 tons per acre-foot were obtained from sands of which the surrounding portions of the sand-body were equally under intensive exploitation, which should preclude the possibility of this high enrichment and recovery being satisfactorily explained away by arguments based on migration from outside as production progressed.

Mr. Ibbett said he entirely disagreed with the remarks that had just been made by the last speaker. There was no question that 90 per cent was a high figure and that it should be considered as the maximum, as the author intended, but there was no doubt that at any rate a minimum of 50 per cent remained in the sands.

Mr. Gordon Pitt said that the suggestion that had been made with regard to using natural gas pressure to force oil out of the wells by

drilling not on the crests of the anticlines was one he had the opportunity of trying some years ago with marked success. To continue on the same lines he desired to point out that while those mechanical suggestions, if he might so call them, as to the way in which an oil-well or an oil production area should be handled after decline began were of enormous importance, and should receive most careful attention from the members of the Institution, there was one side of the matter which was still too much neglected. It has been referred to very briefly by the author and he would like to extend the reference that had been made to it. Whilst it was a most desirable thing, after having got a well down into producing sand, to increase the actual area of drainage of that particular hole as much as might be practicable, it was, in his opinion, quite as important to see that the perforation was made under the best possible conditions. He was prepared very strongly to support the statement that more harm could be done in the first quarter of an hour after the casing penetrated the oil sand than could ever be overcome afterwards. That, at any rate, was the case in territories which he knew best, like Trinidad, where the pressure problems were so difficult and where somewhat imperfect knowledge was possessed of the stratification. There were two main ways in which the harm to which he had referred could be obviated. It was, in his opinion, a great mistake to leave the actual bringing in of a well, i.e. the final perforation of the oil sand, in the hands of the ordinary driller, but as soon as the geological information available indicated that he was within reasonable reach of the oil sand an expert man should be put on to the job. The average driller's ideal was a gusher. On the other hand, he desired to make the positive statement that in his opinion a gusher was a very bad thing. In a great many instances, if the well was not allowed to come in as a gusher, when that could be prevented, the actual production from the well would be increased considerably. While the opening up of the drainage area from which each hole was to draw was vitally important, an equally vitally important point to ensure that drainage area and to make quite sure that it could later on be opened up to its full extent was not to open up in the wrong way to begin with. It was a mistake that the oil should come up from the sand formation without the sand. If that happened it meant that very soon no more oil would be forthcoming. It was most important to try and get the proper proportionate amount of sand away with the oil all the time—not too much and not too little—and that was why in many cases packing and straining and letting the oil come up with no sand at all were a vital mistake.

Mr. Evans said he desired to ask Mr. Gordon Pitt a question in reference to the remarks he had made. As he understood Mr. Gordon

Pitt's argument, it was that the best thing to do was to drill on a flank. He would like to know how the oil-sands could be touched, if there was a great pressure, without a gusher forming. He desired also to ask what actual pressure was used, within a very approximate range, when compressed air was utilized. Dr. Ormandy had referred to the possibility of making the water slightly alkaline. On reading the paper first, he rather imagined that the statement made that "experiments made by passing water through partly drained sand reveal a tendency on the part of the water to surround bodies of oil" meant small particles, and that therefore emulsions were formed. Was that a fact, or did the author mean large volumes of oil? If that was not so and it was a question of forming emulsions, he thought the addition of the alkali would increase the tendency of the water to form emulsions.

Dr. Ormandy said that he referred to bulk displacements through the porous medium.

Mr. Evans thought that if there was a tendency for the water to form emulsions the suggestion which Dr. Ormandy had made with regard to adding alkali might be extended to the use of aluminium salts, which it was known had a very strong tendency to break emulsions.

Mr. Gordon Pitt said he desired to make it clear, in connection with his previous remarks about drilling on the crest of an anticline, that in working it was usually an advisable thing to attempt, if possible, to tap situations where the gas pressure would still be retained by the earth formation in such a way as to force the oil out, rather than to come in on the highest point for gas. He also desired to say that his principal object in making his remarks was more than achieved by the excellent speech that had been given by Mr. Ibbett.

The President said that a very interesting discussion had taken place on points which had arisen directly as the result of the paper and on other subjects a little wide of it, but that was all to the good. He did not propose to take up the time of the meeting by making any further contribution to it, except to ask that a little more light should be thrown on what the author intended to convey in his concluding remark, "There is good reason to anticipate that application of the principles advocated may in time lead to recovery of oil from sources which are inaccessible to the drill."

Mr. A. Frank Dabell, in reply, said that the President had asked that further light should be thrown on the question referred to in the concluding paragraph of the paper with regard to reaching oil which was inaccessible to the drill.

This referred to surface areas covered by rocky precipices, mud

lakes, etc., and to subterranean areas enclosed within steeply dipping strata.

He thought that the most relevant criticism adduced had been that of Mr. Ashmead Bartlett, who pointed out that if the gas were left in the domes that gas would do the work which otherwise had to be performed artificially.

Unfortunately on many fields that gas had been allowed to escape and the value of its expanding and propulsive effort lost, and whilst in some cases encroaching water then became a propellant it was not subject to control.

Reference had been made to air driving the oil, in the sense that it pushed it forward. This might apply to water, but not to air. He thought the action of the air was to aerate and vitalize the oil and encourage it to migrate, and although Mr. McQueen's criticism that such would volatilize the lighter fractions would follow, it was this effort toward volatilization which afforded the desired movement, and the use of gasoline plant should prevent loss. On the whole, aeration was to be welcomed, for it meant locomotion.

The creation of emulsion by pumping down water need not be feared, for emulsion, as a rule, arose from agitation, which would not occur under the low rate of movement recorded at Bradford, although he agreed with Mr. Anfilogoff that every effort should be made to avoid it.

The suggestion of Dr. Ormandy that the water be made alkaline was of very doubtful advantage, but he agreed with Mr. Gordon Pitt as to the necessity for enlisting the sympathy and assistance of geologists and chemists in all pioneer work.

Mr. Dabell remarked that many of the critics were from Trinidad, a most unfortunate location for applying the principles enunciated, unless some continuity of formation had been recently determined there.

He concluded by asking members to appreciate that the main purpose prompting the reading of the paper had been to stimulate interest in better production methods and to call for the better circulation of literature bearing upon the subject, for experiments made with success in one field were often not heard of in another for sometimes one or two years.

He suggested that the Administrative Boards in London could to advantage take an interest in the matter by circulating among their men on the distant fields all literature bearing upon the science of the subject. He called particular attention to the valuable brochures published by the U.S. Bureau of Mines.

A resolution of thanks, proposed by the **President,** was carried by acclamation and the meeting terminated.

Contribution from Mr. MAY.

A good deal of the discussion has centred around the various applications of air for extracting oil from wells, and the loss of light products entailed, particularly with light crudes. Oil is ejected by air lift as a spray when the level is low in the well, resulting in a serious loss of the lighter constituents, but this can be overcome by installing an enclosed circuit. The pressure in such a circuit must be well below 500 lb. per square inch to avoid spontaneous ignition should the ratio of air to gas be less than 10 to 1, which ratio must also be borne in mind with an open circuit should the gas be conducted to boilers or otherwise used as fuel.

Should sufficient gas be available it can be substituted for air in an enclosed circuit, thereby eliminating danger and at the same time enabling the gasoline to be extracted on the passage of the gas through the compressor.

The writer is interested at the moment in a problem of this nature, the air lift having resulted in a considerable increase in the production, but it was found that the valuable light products were lost. As a result an enclosed circuit is being installed using gas instead of air, which it is anticipated will give satisfactory results.

Contribution from Mr. R. S. WARD.

In dealing with methods introduced for the purpose of arresting decline, Mr. Dabell mentioned that the choice of a suitable propulsive medium lies between gas or liquid, and quotes the use of same with beneficial results. Such methods, to my mind, can only be made use of when control over large areas is possible and a more general understanding between operating companies exists.

In cases, such as Burma, where Mr. Beeby Thompson mentioned in his paper that drilling areas are of 60 feet diameter only, and usually owned by various competing companies, the methods suggested above would hardly be practical. It has been my own experience, working in Burma, that, owing to this closeness of wells, other people's production has benefited from temporary shut downs of one's wells whilst pulling tubing, changing cups, or other reasons that cause loss of pumping hours, and vice versa. Such intensive drilling very soon lowers the gas pressure, and with a gradual lowering of temperature of the producing sands they early become " waxed " up (the oil from this field being light and of a paraffin base) and production very much hindered.

For the purpose of reviving production in certain wells we ran in

hot crude oil and the results we obtained were very beneficial. The heat of the oil tended to liven up the producing sands, and by melting the wax lowered the viscosity of the oil, thereby causing a more ready flow. In each case increase of gas was temporarily noticeable.

The procedure we employed was briefly as follows: From 50 to 100 barrels of crude oil contained in tanks near the well were heated to from 200° F. to 212° F., or as near as possible, by means of steam coils placed inside tanks. The heated oil was run in through the casing-head between the casing and outside the tubing. Whilst running in the oil careful note was made of the expansion of the tubing and casing, due to the increased heat, for fear of accidents. With the exception of one well, where 25 barrels were lost, we obtained back all the oil we poured in—some seven or eight wells being treated, and in nearly every case production was certainly temporarily benefited. The fear of losing one's oil to one's competitors made the undertaking somewhat hazardous for those responsible for its inception, but the results were well worth the risk taken. In another case hot water was used, but with not such good results. The opinion I gained was that wells if so treated at regular intervals would gradually respond to treatment and that much of the oil usually left intact in the sand was recoverable. Better results, I consider, would be possible if the wells under treatment were shut down for some two or three hours, this would allow of the heated oil permeating further into the supply sands and of livening them up more fully, pumping afterwards being restarted. Given a large tract of territory to deal with and little fear of losing your oil to your neighbour, I think the above method would be even more beneficial, and equally so with wells of asphaltic base.

Insulating Oils—Colour and Sludging Characteristics.

By E. B. Wedmore, M.I.E.E.

Arising out of a research initiated by the Institution of Electrical Engineers into the properties of mineral oils used for insulating purposes, a series of tests were carried out by the Metropolitan-Vickers Electrical Co., Ltd., on the relationship between colour and sludging characteristics.

These researches have now been transferred to the Electrical Research Association, which body has decided to publish this particular piece of work as much on account of its exhibiting the technique of tintometer measurements with oils, as of the direct results obtained.

The darkening in colour which takes place as a preliminary to sludging in transformer oils may be utilized as a measure of the tendency to sludge, and since changes of colour may be obtained without submitting the oil to conditions more severe than would normally arise in practice, such darkening may form a method of ascertaining comparative sludging tendencies of particular convenience in dealing with modern so-called non-sludging oils.

The Lovibond Tintometer, No. 7 Set, was found unsuitable for this investigation, the glasses being inadequate both in number and variety of colour. In the apparatus employed, the four petroleum glasses were replaced by a set of colour standards, in each of the colours, red, yellow and blue. About thirty glasses for each colour were obtained, a figure being associated with each expressing quantitatively, but arbitrarily, the depth of tint from 0·01 in the lighter to 20·0 in the deeper tints. The individual glasses were selected so that practically any depth in any colour could be built up by the use of a small number of glasses, thus avoiding possibility of error due to reflection or refraction at the surfaces of the glass slips.

The samples of oils tested were submitted to a series of sludging tests in accordance with the method outlined in the Report (*Journal of the Institution of Electrical Engineers*, 1916, Vol. 54, p. 497). Each set of samples was sludged at 60°, 70°, 80°, 90°, 100°, 110°, and 120° C. for 45 hours, two or more tests being taken at each temperature, and when no sludge formed the oil was tested in the tintometer.

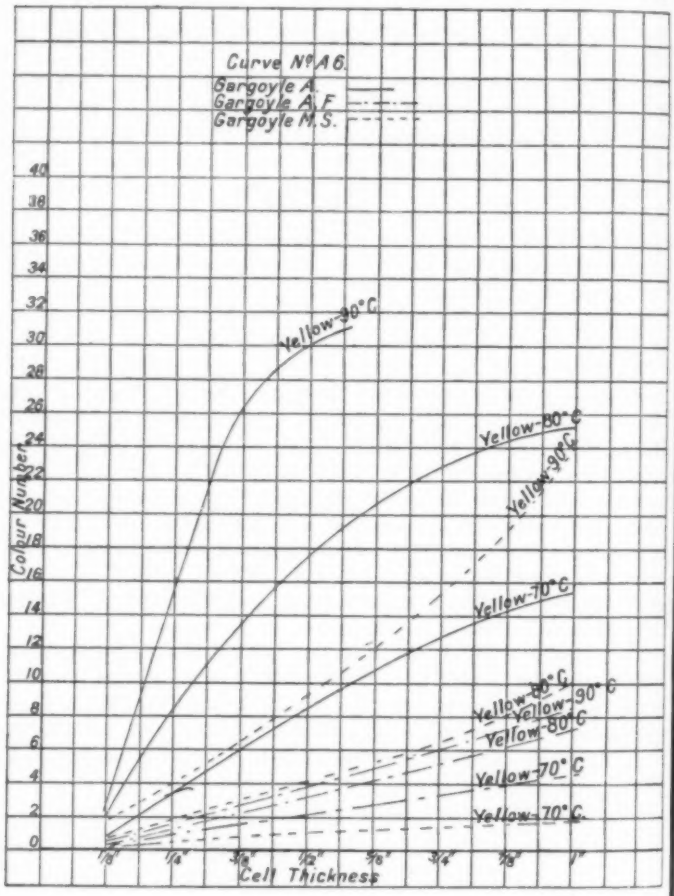
The oils tested were as follows :—

1. Gargoyle A.
2. Gargoyle AF.
3. Gargoyle MS.
4. Immutol.

5. Recsileo S.O.X. (Unused).
6. Recsileo S.O.X. (Partly used).
7. Recsileo AB2. (Partly used).
8. Stern Sonneborn X. 26097 (a pre-war quality).

Of these oils, three sludged at 100°, 110°, and 120° C., namely Recsileo AB2, Gargoyle A, and Gargoyle MS.

All oils at 120° C. were filtered, except Stern Sonneborn. Colour tests were not taken when sludge was produced. The non-sludging



oils were tested in the tintometer in cells $\frac{1}{8}''$, $\frac{1}{4}''$, $\frac{1}{2}''$, and $1''$ in thickness, and the necessary match was made with standard glasses.

The Lovibond Tintometer.

In this instrument pure red, yellow, and blue colours are matched by a single glass from the corresponding colour scale, while orange, green, and violet are matched by a combination of two glasses from two standard scales—red and yellow for orange, yellow and blue for green, and red and blue for violet. The combination of three colours in equal proportions gives a neutral tint. Complex colour sensations are matched by unequal glasses from two standard scales and the colour expressed by the addition of the values of the glasses used is generally transformed into the colour actually developed and transmitted to the eye. Thus in a colour matched by 12·0 units of red and 7·5 units of blue, equivalent properties of red and blue combine to give violet and the excess of red remains. The colour equation then becomes

$$\begin{array}{l} \text{Red} + \text{Blue} = \text{Violet} + \text{Red.} \\ 12{\cdot}0 + 7{\cdot}5 \;\; = 7{\cdot}5 \;\;\; + 4{\cdot}5 \end{array}$$

also :

$$\begin{array}{l} \text{Red} \pm \text{Yellow} \pm \text{Blue} = \text{Neutral} \pm \text{Green} \pm \text{Blue} \\ 5 \;+\; 12 \;+\; 16 \;=\; 5 \;\;+\; 7 \;+\; 4 \end{array}$$

Should a complex colour be brighter than the standards, neutral tints may be interposed to cut down the brightness before matching. The excess brightness is shown in the equation in the form of light units, thus :—

$$\begin{array}{l} \text{Light (neutral)} \pm \text{Yellow} \pm \text{Blue} = \text{Light} \pm \text{Green} \pm \text{Yellow} \\ 3 \;\;\;\; + \;\; 5{\cdot}5 \;+\; 3{\cdot}5 \;=\; 3{\cdot}0 \;+\; 3{\cdot}5 \;+\; 2 \end{array}$$

i.e. a yellow-green three units brighter than standard.

All colours are measurable by a combination of glasses with or without a light or neutral factor, and the colour can be stated in quantitative terms.

The colour given by the standards was transformed to the colour transmitted, and the number for each colour comprising the transmitted colour sensation at each temperature was plotted against cell thickness, thus giving the so-called colour-absorption curve (Group A).

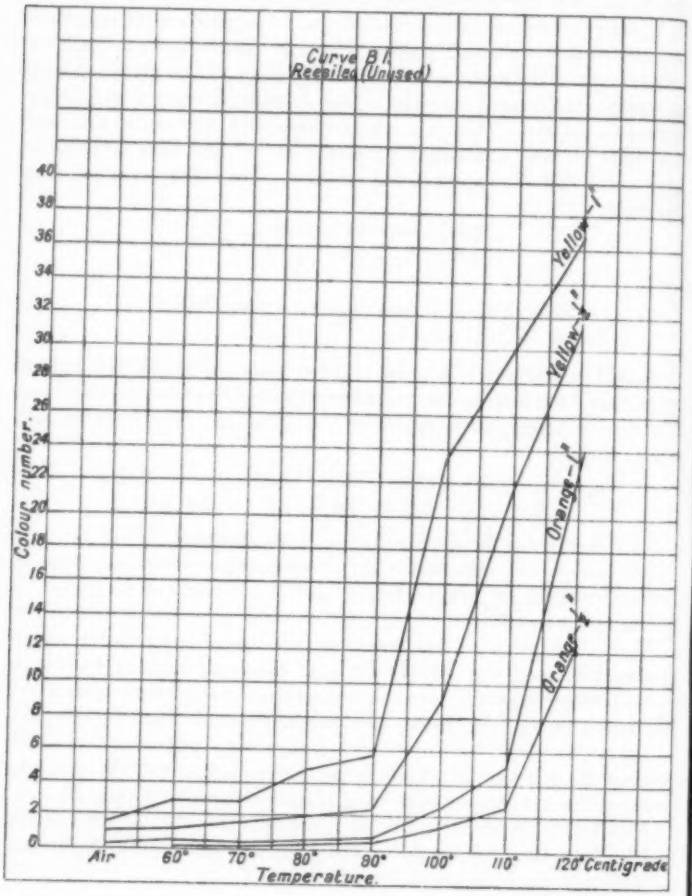
Colour numbers for yellow and orange were plotted for each oil against the temperature at which the colour number was obtained, the readings for the various cells being plotted separately (Group B).

Finally, the characteristic colour chart was made by plotting yellow vertically against orange horizontally for the various cell thicknesses at different temperatures (Group C).

Results.

The predominating colour in the results is yellow. From the tintometrical point of view this is unfortunate as yellow is the most difficult colour to manipulate and to match accurately. It is inadvisable to use any cell thickness necessitating a yellow glass greater than 30.

The colour absorption curves show that colour depth does not increase proportionately with temperature. The most striking result obtained is in the set of curves in Group B, which shows that the colour



for a fixed stratum thickness changes very slowly up to a certain temperature, and then it changes rapidly. For the better oils the change point appears to be retarded to about 90° C., whereas in the oils which deposited the sludge the change takes place at 60°–70° C.

The oil No. 5 Reesileo AB2, exhibited the greatest peculiarities with regard to colour change and the curves are apparently very irregular.

Inferences.

1. Increase in cell thickness is followed by increased depth in colour transmitted for each constituent colour.

2. The greater the temperature of sludging the greater is the rate of increase of colour number for all colours. This rate of increase is not proportional to temperature, but is uniform for lower sludging temperatures (60°–90° inc.) for the cells employed.

3. The initial colours of the transformer oils tested are sufficiently similar to render influence of initial on the final colour to be disregarded.

4. There does not appear to be any direct indication of commencement of sludging by colour change and the colour change appears to be gradual.

5. Colour temperature curves for a definite stratum thickness indicate that colour number increases slowly at first, but as temperature is raised the increase becomes more rapid. For the better oils the change takes place at 90° C., while for those which deposited sludge the change appears to be at 60°–70° C. This appears to be the clearest indication of sludging tendency given by the curves.

6. The presence of sludge in the oil does not appear to exercise any appreciable influence on the colour number.

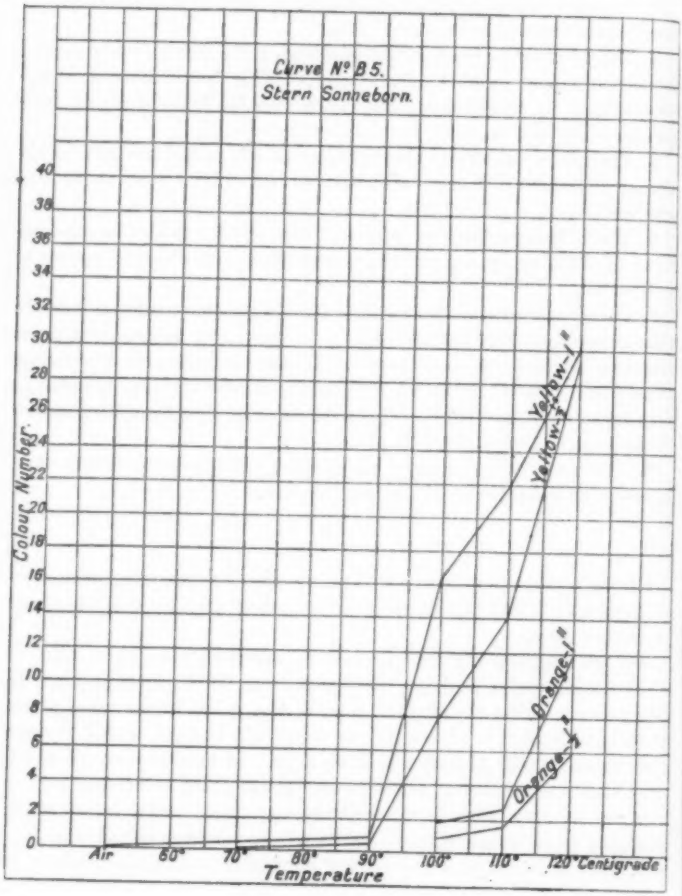
Conclusions.

Colour tests cannot be relied upon as criteria of sludging characteristics of an oil, and cannot therefore be substituted for other methods of examination.

The most promising test appears to ascertain the colour number after testing under sludging conditions from 60° C. upwards, and to determine whether the upward bend in the yellow curve takes place. If this is retarded to above 90° the oil should be good, and if it commences at 60°–70° the oil would be poor. In this way an oil which may sludge copiously at temperatures above those secured in service and yet be very suitable at service temperatures would be detected. Sludging an oil at several temperatures, however, is so tedious that it is not likely to be adopted as a general method of testing, particularly as

the advantages to be gained by such a refinement do not appear at present to be worth the extra trouble involved.

In tracing the relationship between colour and sludging characteristics the tintometer has proved admirably adapted for studying the colour changes. For comparison between colours as colours it has the advantage of offering a quantitative means of colour estimation far in advance of the usual method of description, particularly when the change is confined to the same tint, and for correlating colour with definite physical properties.



Colloid Chemistry of Petroleum.

By Dr. A. E. Dunstan.

Abstracted, by permission, from the British Association's Third Report on Colloid Chemistry (Dept. of Scientific and Industrial Research).

Crude oil of the paraffin base type (i.e. oil which on distillation yields solid paraffins in the high boiling fractions) usually contains colloidal amorphous matter which only assumes the crystalline state after distillation. It is probable that the effect of heat in this case is physical, bringing about a change of state whereby the wax is no longer in the dispersed condition characteristic of the original oil. Such oils and their residues after the removal of benzine and kerosene are frequently highly viscous, particularly at low temperatures, owing to the "setting" of the paraffin sol.

The black or dark coloured "ashpaltic base" oils contain bituminous matter which is to be regarded as being derived from the petroleum hydrocarbons by oxidation (and sulphuration) and condensation. These oils are optically heterogeneous, although in most cases the degree of dispersion is very high (*see* Holde, *Koll. Zeits.*, 1908, **3**, 270; Schneider and Just, *Zeit. f. Wiss. Mikrosk*, 1905, **22**, 561).

The colloidal asphalts may readily be coagulated by means of strong sulphuric acid (Schultz, *Petroleum*, **5**, 205, 446). The chemistry of the well-known "acid treatment" has been investigated by B. T. Brooks and I. Humphrey (*Jour. Amer. Chem. Soc.*, 1918, **40**, 822). The usually accepted view that olefines are polymerized to tar and removed as sludge is erroneous, for pure olefines (up to the C_{16} member) do not give tars with acid up to 100 per cent strength at 15° C. The formation of "acid tar" is probably a dual phenomenon—firstly, the acid coagulates the colloidal matter present in the oil; and, secondly, it brings about polymerization of olefines and diolefines, sulphonation of aromatic derivatives, together with oxidation of primary materials and products.

Pyhälä (*Zeits. Chem. Ind. Koll.*, 1911, **9**, 209) considers that crude oils are sols of which the disperse phases are solid gels such as asphalt, together with liquid particles. When the disperse phase exceeds 60 per cent the phenomenon of gelatinization makes its appearance.

In the discussion on a paper by Glazebrook, Higgins, and Pannell (*Jour. Inst. Petr. Techn.*, 1915, **2**, 54 *et seq.*), the writer brought forward the peculiar hysteresis effect in the viscosity of fuel oils and showed that by a suitable alteration in the previous history of a given oil, wide variations in its viscosity may be effected.

The colloidal asphaltic matter in crude oil and the yellow colouring matter in benzine, kerosene, and other distillates which is largely caused by "tar-fog" mechanically carried over, may be removed by coagulation (and solution) by agitation with strong sulphuric acid. Direct adsorption on specific surfaces, however, is equally effective. The writer has shown that floridin, fuller's earth, and bauxite which, when freshly ignited, possess powerful adsorptive action, follow the well-known exponential absorption rule:—$Y/_m = ac^{\frac{1}{n}}$. For example, using a 0·25 per cent solution of a crude asphaltic base oil in benzine as a test liquid, constant values of n were obtained and the $Y/_m$—c curves were of the usual parabolic type.

The application of the adsorptive action of these substances in the refining of various distillates is well known, and much of the theoretical side has been admirably expounded by Day and his co-workers, by whom the following conclusions were arrived at:—

(1) Fuller's earth tends to retain the unsaturated hydrocarbons and sulphur compounds in petroleum, thus exercising a selective action on the oil.

(2) When crude petroleum diffuses upwards through a column of fuller's earth a fractionation of the oil occurs. The oil displaced by water from the earth at the top of the tube is lower in density than that from the bottom of the tube.

(3) The aromatic hydrocarbon in a mixture of a paraffin oil and benzene tends to collect in the lower end of the diffusion column.

In this connexion an interesting observation was made by Herr (*Petr.*, 1909, **4**, 1284), who filtered Baku oil through fuller's earth and discovered that all the formolite forming compounds were removed, i.e. the unsaturated compounds which react with formolin were adsorbed on the mineral gel.

It by no means follows that the compounds which are adsorbed can be recovered unchanged. Being possessed almost invariably of residual affinity the close contact afforded in the adsorbed layer promotes condensation and polymerization, and thus Gurwitsch (*Jour. Russ. Phys. Chem. Soc.*, 1915, **47**, 827) was able to show that

Floridin brings about active polymerization when brought into contact with amylene and pinene, resulting in considerable rise in temperature. Curiously enough the same polymer, di-amylene, is produced both by sulphuric acid and by fuller's earth. Alumina behaves in the same way towards amylene, but is apparently without effect on pinene. Freshly ignited precipitated alumina is particularly effective as a decolorizing agent for petroleum and its distillates, and a series of experiments using a 0·25 per cent solution of crude asphaltic oil in benzene showed the following order:—

Material (1 gram).	cc. of coloured solution decolourized.
Alumina	60
Fuller's earth I	30
Bauxite I	30
Bauxite II	25
Bauxite III	20
Ignited peat	15
Bone charcoal	14
Bog iron ore	12
Fuller's earth II	10
Ferric oxide	10
Ball clay	8
Fuller's earth III	8·5
Fuller's earth IV	4
China clay	2
Kieselguhr	2

The temperature at which the adsorbing surface exerts its specific effect is of some importance. Gilpin and Schnerberger (*Amer. Chem. Jour.*, 1913, **50**, 59) on passing Californian crude oil through fuller's earth found little fractionating effect at 20° C. but a satisfactory result at 70° C.

Similarly cold bauxite, which has been ignited and cooled in a vacuum desiccator, was found to have lost its power of adsorbing sulphur derivatives from kerosene. When freshly heated (to 200° C.) its activity in this direction was regained. Heat appears to be evolved during active adsorption, thus a 20° C. rise in temperature was observed during the passage of 100 cc. of kerosene through 50 grams of bauxite.

Amongst other effective materials may be mentioned Kambara earth; fibrous alumina has been recommended by Gawolowski (*Allg. Oesterr. Chem.*, 1908, **26**, 87), whilst animal charcoal and prussiate residues have long been employed for these purposes.

Naturally the degree of fineness of the absorbent is important. The following case will illustrate this point :—

Bauxite Mesh.	Activity.
40/60	1·0
60/80	1·7

In point of fact the activity—all experimental conditions being the same—is approximately directly proportional to the mesh. A convenient method of demonstrating this point consists in treating a 100 cc. of coloured solution (as e.g. that already mentioned) with varying weights of decolorant, matching the filtered resultant solution with the standard solution in a Nessler jar (C. ccs.) and plotting $\frac{100\,C.}{\text{mass}}$ against C. Ordinates at C=50 give directly the reciprocals of the masses required to remove 50 per cent of the colour. Thus with floridin :—

Mesh.	Mass.
Passing 180	50/320
Passing 80 and retained on 180	50/170
Passing 20 and retained on 30	50/44
and with Bauxite	
Passing 80	50/175
Passing 60 and retained on 80	50/80
Passing 20 and retained on 30	50/30

The essential feature of all effective adsorption agents is development of surface, hence mineral gels containing water of combination which, on ignition, possess a characteristic structure are decidedly likely to possess decolorizing and desulphurizing properties.

Very characteristic is the behaviour of bauxite (say, 40/60 mesh) on being gently agitated with kerosene or benzene. Apparently a process of peptization goes on, for a considerable amount of very finely divided material separates in suspension in the petroleum, and is sufficiently fine to pass readily through filter paper (*see* W. Bancroft, Vol. II, *Report on Colloid Chemistry*, 1918, p. 2 *et seq.*)

Although in actual refining operations the adsorptive properties of the materials described above have mainly been directed towards the removal of colour, yet considerable success has been achieved in connection with the equally important problem of desulphurization. It by no means follows that an adsorbent is equally effective in removing colouring matters and sulphur derivatives. Usually this is not the case, and each material must be tested for its specific purpose.

An interesting application of adsorption is to be seen in the method patented by Hall Motor Fuel, Ltd., for the purification of cracked spirit. This material, as is well known, contains a considerable proportion of highly unsaturated hydrocarbons—olefines and diolefines—to the presence of which it owes its characteristic odour and its objectionable propensity towards resinification or "gumming." Although the reactive hydrocarbons can be removed by the agency of strong sulphuric acid, the operation is attended by serious loss, but by utilizing the adsorbent capacity of floridin, the diolefines present are polymerized to high boiling products and a spirit free from objection is produced. The refining operation is best carried out with the spirit in the vapour state; under these conditions adsorption is followed by condensation and/or polymerization. Incidentally the sulphur derivatives present in many benzines and kerosenes may be removed in a precisely similar manner.

The problem of the breaking of persistent emulsions in refining operations is obviously one for treatment by the application of colloid chemistry. The soda wash which is employed to remove the traces of sulphuric acid in the refining of lubricating oils is a common source of this trouble, and in some cases a practically permanent emulsion is formed. The sodium salts of naphthenic and sulphonated naphthenic acids are notable emulsifying agents and it is possible that herein lies the cause of what is sometimes a serious difficulty. It is interesting to remember that sodium naphthenates are used very extensively as soap.

A recent patent by Southcombe and Wells brings out the novel point that a small amount (1 per cent) of free fatty acid, added to a mineral lubricating oil, not only replaces the usual blending fatty oil, but according as its molecular weight is low or high, yields a non-emulsifying or an emulsifying oil. It appears that the addition of the free fatty acid appreciably lowers the interfacial tension between the lubricating oil and the bearing.

Petroleum jelly or "vaseline" appears to be an emulsion of soft paraffins dispersed in heavy oils. The viscosity increases gradually with decreasing temperature until the gel state is attained, without, however, any separation of crystalline wax, but on being distilled, wax appears in the distillate. Various artificial jellies are on this market, being compounded of soft wax and heavy oils; these, on the contrary, are inclined to deposit crystalline matter on being cooled, and do not possess the salve-like nature of the natural product.* An apt comparison

* By this is meant the material which is obtained from a suitable crude oil by distilling off the lighter compounds and decolorising the residue (usually by filtration through fuller's earth).

is in the different appearance of ice cream made with and without the addition of gelatine, and in both cases—vaseline and ice cream—the presence of a protective colloid may be the explanation.

A peculiar illustration of the coagulation of a colloidal solution is seen in the action of flowers of sulphur on the yellow liquid which is produced by treatment of sulphur-containing distillates with sodium plumbite. There is a rapid flocculation and a dark brown precipitate appears.

According to Wo. Ostwald (*A Handbook of Colloid Chemistry*, p. 103), petroleum oil fractions of high boiling-point are to be classed as iso-colloids, i.e. a category in which disperse phase and dispersion means possess the same (or analogous) chemical composition.

The ultra-microscopic examination of a number of mineral lubricating oils (Dunstan and Thole, *Jour. Inst. Petr. Tech.*, 1918, **4**, 191) has demonstrated that optical heterogeneity exists, although, however, the degree of dispersion is exceedingly high. The same behaviour obtains for the fatty oils, and it is possible that lubricating power is in some way connected with this iso-colloidal state.

Lubricating greases are examples of oil-water emulsions stabilized by soap. Commonly sodium soaps are used for motor greases, and the proportions are lubricating oil (sp. gr. ·900–·910), 80 parts; stearine acid, 15 parts; and caustic soda, 2 parts. Part of the oil is mixed with the stearine acid, and this is added to the soda in 40 per cent aqueous solution, with constant agitation. The remainder of the oil is then incorporated. Cheaper greases are compounded with lime soaps.

Acheson's oil-dag and aqua-dag are suspensoids of graphite in oil or water containing a protective colloid (tannin). Aqua-dag is made first, and the graphite is transferred from this to oil. The oil-dag contains about 15 per cent of "deflocculated graphite" and is used in a dilute solution of lubricating oil (0·1 per cent graphite) with beneficial results to the bearings, which gradually become coated with a "graphitoid" layer.

The colloidal graphite in oil-dag may be removed for analysis in two ways. Freundlich (*Chem. Zeit.*, 1916, **40**, 358) throws out the graphite by adding an electrolyte (acetic acid) to the benzol solution of the oil-dag whilst Holde (*Zeit. f. Elektrochem*, 1917, **23**, 116) adsorbs the graphite on recently ignited fuller's earth in a Gooch crucible. A German proprietary material named "Kollag" appears to be similar to oil-dag.

The influence of colloidal bituminous matter which is mechanically carried over during distillation is frequently sufficient to prevent the easy separation of paraffin wax from that fraction known as "heavy

oil and paraffin," and recourse is made to a sulphuric acid treatment before refrigeration. The paraffin scale is usually discoloured and contains a greater or less amount of uncrystallizable material which is removed by the process of "sweating," i.e. fractional fusion. This operation serves to raise the melting-point of the wax and also in part to purify it. Final discolorization is effected by filtering the melted wax through fuller's earth, bauxite, or prussiate charcoal.

The Colloidal State of Matter in Its Relation to the Asphalt Industry.

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Abstracted, by permission, from the British Association's Third Report on Colloid Chemistry (Dept. of Scientific and Industrial Research).

THE presence of mineral matter in a high state of subdivision in a system solid-liquid, the latter phase consisting of asphalt, reveals some interesting phenomena, connected with the relation of surfaces of solids and films of liquids, particularly where the mineral matter is sufficiently subdivided to exist in a colloidal state as regards the bitumen. Owing to the viscosity of such a continuous phase the particles of mineral matter with which it is associated may be regarded as a colloidal state, although they may be of dimensions which would prevent their existence in such a state with a more mobile liquid, such as water. Clay and finely divided silica present such a relation to a highly viscous liquid, asphalt for instance, which may be regarded as a colloidal one. Attention was attracted to the subject in the course of a study of the native asphalt found in the Pitch Lake in the Island of Trinidad, British West Indies. This deposit is unique from a geophysical standpoint. It exists in a crater of an old mud spring on the West Coast of the island, and at a distance of about half a mile from the Gulf of Paria. Its surface was originally 138 feet above sea-level. Borings which have been recently made show that the crude asphalt exists to a depth of more than 175 feet at the centre of the deposit, which consists of a bowl-shaped mass covering, originally, an area of 114 acres. Specimens taken at various points on the surface and at different depths show that it originates in an asphaltic petroleum derived from oil sands occurring at considerable depth below the lake, with which a paste of mineral matter and water, originating in a mud

spring, has become associated by the churning action of the natural gas accompanying the petroleum, on the release of the pressure to which it has been subjected as the oil approaches the surface. The material formed in this way is of highly uniform composition in all parts of the deposit, and consists of an emulsion of bitumen with a paste of clay and fine sand, and has the following composition :—

	Per cent.
Bitumen	39
Mineral matter	27
Water and gas, volatile at 100° C. . .	29
Water of hydration of mineral matter . .	5
	100

In determining the percentage of bitumen in the refined material by means of solvents it is found that some of the mineral matter passes through the finest filters and is not removed from the solution on prolonged centrifuging. On examination under the ultra-microscopic it is revealed that it consists of clay in a colloidal condition, originating in the mineral matter of the mud spring in which it existed in this state as regards the water with which it is associated, and which is introduced into the bituminous phase on the removal of the water on refining. The amount of mineral matter in the colloidal state depends on the concentration of the solution, that is to say, upon its viscosity.

In dilute solution it appears that the amount of matter in a colloidal state is comparatively small, but with increased concentration, that is to say, with increased viscosity of the continuous phase, it becomes progressively larger until in the refined asphalt itself all of the mineral matter, at ordinary temperatures, may be regarded as in a colloidal state. Trinidad asphalt appears, therefore, to be a material the components of which are in a state of equilibrium, and this accounts for its uniform composition. It is, therefore, a unique material, and it is to the large amount of surface energy developed by the highly divided mineral matter which it contains that the demonstrated industrial value of the asphalt is to be attributed.

The Introduction of Colloidal Clay into the Purer Forms of Bitumen.

In the light of the preceding facts the inference was drawn by the writer that clay in a colloidal state might be introduced in a similar manner, industrially, into the purer forms of asphalt, and

into the residual asphalts prepared from petroleum. For this purpose, a paste of clay and water, in which the clay was in a colloidal state as regards the water, was emulsified with residual asphalts from various types of petroleum. The water was then driven off at high temperatures and it was found that the relation of the clay to the bitumen became a colloidal one. The proportions were so selected that the resulting material, after the removal of the water, should consist of 67 per cent bitumen and 33 per cent of clay. These materials were then maintained in a melted condition in tubes for 24 hours, at a temperature of 325° F. The sedimentation which ensued, with the reduction of the viscosity of the continuous phase at this high temperature, varied with the different residuals, and was as follows :—

Source.	Penetration.	Per cent. Colloidal Matter.		Per cent. Sedimentation.
		Before Subsidation.	After Subsidation.	
Trinidad Residual .	50	33·5	33·7	0·0
Bababui ,, .	48	32·4	30·1	7·0
Mexican ,, .	50	33·3	27·2	18·3
California ,, .	50	31·8	23·8	25·2
Mid-Continental Semi-Paraffin Residual.	51	33·8	21·7	35·8

Industrial Application.

Industrially these observations are of importance, especially in the construction of asphalt pavements. Experience has shown that the stability of such a surface under heavy travel is dependent on the amount of surface energy developed by the mineral aggregate, that is to say, by the state of subdivision of the particles composing this aggregate. While this will depend upon the size of the sand particles and of those composing the filler, it is also contributed to by the highly developed surface of the colloidal components of Trinidad asphalt and to an extent which would be entirely lacking if the purer forms of bitumen were used with the aggregate, a fact which has been demonstrated by the difficulties which have been encountered in the construction of asphalt surfaces with the residual pitches, free from colloidal mineral matter, which have been met with in the past decade in England, and which have necessitated the employment of various expedients to overcome them.

The relation of surfaces of solids to films of liquids, especially when the surface is developed to such an extent as occurs in material in a colloidal state, has been demonstrated, therefore, to be a matter of supreme importance in carrying out successfully the construction of asphalt roadways to carry intense traffic.

[NOTE.—A more detailed account of the colloid chemistry of asphalt is given in the following paper: "The Colloidal State of Matter in its Relation to the Asphalt Paving Industry," C. Richardson, Minnesota Engineering Society, May, 1917. W. C. McC. L.]

Current Bibliography.

Compiled by W. J. Wilson, A.G.G.I., A.I.C.

Geological.

Action of Certain Rock Formations on Petroleum, The.—E. Longobardi. *Anales Soc. Quim. Argentina* **7**, 418. *Chem. Abstr.* **15**, 3058.

Agate Anticline, Sioux County Nebraska, The.—Kanoka Petroleum Co.

Debt of Geology to the Petroleum Industry.—E. de Golyer. *Bull. of the American Association of Petroleum Geologists.*

Field Mapping for the Oil Geologist.—C. A. Warner. J. Wiley & Son.

Geology of the Peruvian Oil-Fields.—V. F. Marsters. *Oil and Gas J.* **19**, (46), 78. *Chem. Abstr.* **15**, 2404.

Gulf Cretaceous Field, The: Types of Oil and Gas Pools.—F. J. Fohs. *Oil Tr. J.* **12** (9), 55.

Huntingdon Beach Field of California, The.—*California State Mining Bureau Bull. Petr. Times* **6**, 759.

Mexia: The Remarkable New Field in Texas.—T. O. Bosworth. *Oil News* **10**, 567.

Mid-Continental Geological Studies.—F. L. Aurin, G. C. Clark & E. A. Trager. *Oil and Gas J.* **19** (51), 84. *Chem. Abstr.* **15**, 2404.

Moving Underground Water as a Primary Cause of Oil Accumulation.—J. L. Rich. *Economic Geology* **16** (6). *Petr. Times* **6**, 849.

Oil and Gas-Fields of Illinois. U.S. Geol. Surv.

Oil-Bearing Rocks of Lower Mackenzie River Valley.—E. M. Kindle & T. O. Bosworth. Canada Department Mines.

Oil-Fields of Northern Argentina.—G. S. Brady. *Petr. World* **18**, 495.

Oil-Fields of Oklahoma.—U.S. Geol. Surv.

Oil Possibilities of Haytl.—U.S. Geol. Surv. *Petr. World* **19**, 20.

Origin of the Anticlinical Oil Theory.—J. von Gal-Scale. *Petr. Times* **6**, 852.

Petroleum Genesis and Geology, Setting Forth Concurrent Conditions.—S.F. Hunt. *Salt Lake Mining Rev.* **23** (6). *Chem. Abstr.* **15**, 3058.

Preliminary Report on Petroleum in Alaska.—G. C. Martin. *U.S. Geol. Surv. Bull.* 719. *Chem. Abstr.* **15**, 2605.

Way to the Discovery of Oil-Fields, The.—J. von Gal-Scale. *Petr. Times* **6**, 640.

Geographical.

Bolivian Mineral Oil Concession Law.—*U.S. Commerce Reports*, p. 315.

Consumption of Petroleum in Chile.—*U.S. Commerce Reports*, p. 78.

Discoveries of Extraordinary Oil Seepages in Eastern Texas.—*Petr. Times* **6**, 631.

Discovery of Petroleum in Western Australia.—*Industrial Australian and Mining Standard. Petr. Times* **6**, 618.

European Oil Conditions and Outlook.—E. Prizer. *Petr. Times* **6**, 827.

Excise Duties on Petroleum in the Netherlands East Indies.—*U.S. Commerce Reports*, p. 182.

German Consumption of Illuminating Oil.—*U.S. Commerce Reports*, p. 206.

How Oil is Produced in Mexico.—W. A. Read. (Caltrex Oil Co.)

Mexican Oil Competition. "The Lamp." *Petr. World* **18**, 502.

Mexican Oil-Fields and Their Future, The.—Superintendent of Mexican Petroleum Co. *Petr. Times* **6**, 639.

Mexico: The Future of Its Oil Business.—E. L. Doheny. *Petr. Times* **6**, 901, 933. *Oil News* **10** (472 Supplement), ii.

Mines and the Refinery of Pechelbronn, The.—P. de Chambrier & J. de Chambrier. *Mat. grasses* **13**, 5784. *Chem. Abstr.* **15**, 2981.

Northern Argentine Petroleum Fields.—*U.S. Commerce Reports*, p. 276.

Oil and Gas in Alberta.—Canadian Government Report. *Oil News* **10**, 646.

Oil Areas of Bolivia.—*Oil News* **10**, 575.

Oil Companies in Rumania.—*U.S. Commerce Reports*, p. 519.

Oil Development in Canada.—*Petr. World* **18**, 508; **19**, 25.

Oil-Field in Siam.—*U.S. Commerce Reports*, p. 519.

Oil Industry in Poland.—S. Bartoszevicz. *Petr. Times* **6**, 824.

Oil in the Philippine Islands.—*U.S. Commerce Reports*, p. 41.

Oil Policy to be Adopted by Japan.—*U.S. Commerce Reports*, p. 407.

Pacific Coast Petroleum Industry.—*Rept. of the Federal Trade Commission*, Pt. 1. Government Printing Office, Washington.

Petroleum Developments in the Argentine.—J. P. Powers. *Pan-American Magazine. Oil News* **10**, 721.

Petroleum Exploration.—*J. Soc. Chem. Ind.* **40**, 406R.

Petroleum—Export of Poland.—*U.S. Commerce Reports*, p. 109.

Petroleum Industry in Mexico.—*U.S. Commerce Reports*, p. 463.

Petroleum Industry in Soviet Russia, The.—*Ekonomicheskaia Zhizn.*, *Oct.* 6. *Petr. Times* **6**, 861.

Petroleum Industry of Mexico, The.—R. H. Flamm. *Petr. Times* **6**, 741, 789.

PETROLEUM INDUSTRY OF POLAND, THE.—S. Janicki. *Petr. Times* **5,** 759. *Chem. Abstr.* **15,** 2716.

PETROLEUM IN ECUADOR.—*Petr. Times* **6,** 829.

PETROLEUM IN ITALY.—*Petr. Times* **6,** 771.

PETROLEUM IN WESTERN AUSTRALIA.—*Ind. Austral.*, Sept. 1, 1921. *J. Soc. Chem. Ind.* **40,** 407R.

PETROLEUM LAWS OF ALL AMERICA.—J. W. Thompson. *U.S. Bur. Mines Bull.* 206.

PETROLEUM REFINING IN CANADA.—*Chem. Age* **5,** 490.

PETROLEUM POSSIBILITIES OF THE ARGENTINE REPUBLIC.—*Dept. of Overseas Trade Report.* H. O. Chalkley. *Petr. Times* **6,** 882.

PETROLEUM TRADE OF INDIA, THE.—*Petr. Times* **6,** 943.

POLAND'S OIL AND WAX RESOURCES.—*Polish Economic Bull. Oil News* **10,** 521.

POLISH CRUDE OILS ANALYSED.—*Oil Tr. J.* **12** (9), 64.

POLISH OIL RESOURCES.—*U.S. Commerce Reports*, p. 519.

PRODUCTION AT THE COMODORO RIVADAVIA FIELDS.—*U.S. Commerce Reports*, p. 314.

PRODUCTION OF PETROLEUM IN EGYPT.—*U.S. Commerce Reports*, pp. 488, 515.

REAL OIL IN AUSTRALIA.—Blatchford. *Oil News* **10,** 527.

RUMANIAN EXPORT DUTIES.—*U.S. Commerce Reports*, p. 419.

SALT WATER MENACE IN MEXICO, THE.—A. McCurdy. *Oil Tr. J. Petr. Times* **6,** 601.

STATISTICAL REVIEW OF THE MID-CONTINENT FIELD FROM 1912 TO 1920 INCLUSIVE.—M. Bates & B. H. Lasky. *Nat. Petr. News* **13** (13), 67. *Chem. Abstr.* **15,** 2715.

TAX ON MEXICAN CRUDE OIL, THE.—*U.S. Commerce Reports*, p. 18.

WHERE LUBRICATING OIL FLOWS FROM SURFACE IN CALIFORNIA.—*The Oil Weekly* **22** (10), 32.

DRILLING AND FIELD OPERATIONS.

CORE SAMPLING AS PRACTISED BY SHELL COMPANY OF CALIFORNIA.—R. M. Barnes. *Petr. Times* **6,** 611.

NECESSITY FOR STEEL DERRICKS IN OIL-FIELD OPERATIONS, THE.—*Petr. Times* **6,** 754.

NEW DEVICES TO REDUCE OIL-WELL DRILLING COSTS.—*Oil Tr. J.* **12** (10), 102.

NEW DRILLING SYSTEM CLAIMS IMPROVEMENTS.—*Oil Tr. J.* **12** (10), 100.

OIL CAMP SANITATION.—C. P. Bowie. *U.S. Bur. Mines Tech. Paper* 261.

OIL-FIELD PRACTICE.—D. Hager. McGraw-Hill Publishing Co.

OIL LAND DEVELOPMENT AND VALUATION.—R. P. McLaughlin. McGraw-Hill Book Co.

RATE-OF-PRODUCTION CURVE AND ITS APPLICATION TO THE VALUATION OF OIL PROPERTIES.—W. W. Cutler. *Petr. World* **18,** 489; **19,** 37.

RELATION OF DRILLING CAMPAIGN TO INCOME FROM OIL PROPERTIES.—W. W. Cutler & W. S. Clute. *U.S. Bur. Mines Reports Investigations* 2270.

UNDERGROUND CONDITIONS IN OIL-FIELDS.—A. W. Ambrose. U.S. Bur. Mines. *Petr. Times* **6,** 897, 921.

PIPE LINES, TRANSPORT, AND STORAGE.

CONCRETE TANKS FOR FUEL OIL STORAGE.—The Portland Cement Association. *Petr. Times* **6,** 627, 660.

DETERMINING TANK CAPACITY OR CONTENTS.—W. F. Schaphorst. *Textile World* **60,** 687. *Chem. Abstr.* **15,** 2945.

FIRE AND EXPLOSION HAZARDS OF COMMERCIAL OILS, THE.—W. Vlachos & C. A. Vlachos. Vlachos & Co., Philadelphia.

MEASURING LIQUIDS IN TANKS. (The Pneumatic Method.)—*The Gas World* (Coking Section) **75,** 14.

REDUCING LOSSES BY EVAPORATION.—C. P. Buck. *Oil and Gas J.* **20** (5), 80. *Chem. Abstr.* **15,** 2716.

SECURITY IN HANDLING INFLAMMABLE LIQUIDS.—*Chem. Age* **5,** 372.

SHIPYARD BULK STORAGE OIL AND PAINT PLANT.—*Engineering* **112,** 632.

Patents.

CHARGES FOR CHEMICAL FIRE EXTINGUISHERS.—G. J. Money. Brit. Pat. 170,390. *J. Soc. Chem. Ind.* **40,** 834A.

FIRE EXTINGUISHING COMPOSITION.—P. A. Crosby, R. R. Matthews & R. B. High. U.S. Pat. 1,375,779. *Chem. Abstr.* **15,** 2701.

METHOD OF FIREPROOF-STORING MOBILE FUEL.—L. W. Bates. U.S. Pat. 1,394,060. *J. Soc. Chem. Ind.* **40,** 837A.

PAINT (FOR CONCRETE) OR COMPOSITION IMPERVIOUS TO OILS, SPIRITS, AND OTHER LIQIUDS.—C. H. Ivinson & G. S. Roberts. Brit. Pat. 169,258. *J. Soc. Chem. Ind.* **40,** 780A.

STORAGE OF INFLAMMABLE LIQUIDS.—V. Scharnagl. Brit. Pat. 152,672. *J. Soc. Chem. Ind.* **40,** 835A.

REFINERY TECHNIQUE.

BLEACHING OF OILS, THE.—Steinau. *Chem. Zeit.* **45,** 559. *Chem. Abstr.* **15,** 3218.

CLAY AS A SUBSTITUTE FOR FULLER'S EARTH.—*Oil, Paint, and Drug Rept. Petr. Section* **100** (21), 9.

DISCUSSION OF ELECTRICAL DEHYDRATION OF CRUDE OIL.—W. G. & H. C. Eddy. *J. Ind. Eng. Chem.* **13,** 1016.

Losses in the Dehydration of Oil.—J. H. Wiggins. *Nat. Petr. News* **13** (26), 59. *Chem. Abstr.* **15,** 2716.

Oil-Field Practice in Handling Crude Oil Emulsion.—S. Born. *J. Ind. Eng. Chem.* **13,** 1013.

Recovering Petroleum from Emulsions by Chemical Treatment.—R. R. Matthews & P. A. Crosby. *J. Ind. Eng. Chem.* **13,** 1015.

Refining of Crude Petroleum, The.—A. H. Low. *Color. School of Mines Quarterly* **15** (2), 3. *Chem. Abstr.* **15,** 2541.

Removal of the Fluorescence of Vaseline Oils.—G. Meyerheim. *Deut. Parfümerie. Zeit.* **6,** 123. *Chim. et Industrie* **5,** 416. *Chem. Abstr.* **15,** 3204.

Treating Mineral Oils with Alkaline Liquor.—H. Burstin. *Petroleum* **17,** 1169.

Patents.

Art of Filtration (of Paraffin Wax from Oil).—H. F. Glair, Assr. to Standard Oil Co. (of Indiana). U.S. Pat. 1,392,758. *J. Soc. Chem. Ind.* **40,** 804A.

Clarifying and Decolorizing Oils.—R. W. Mumford. U.S. Pat. 1,377,021. *Chem. Abstr.* **15,** 2742.

Method for the Purification of (non-Liquid) Hydrocarbons.—J. M. Treneer. U.S. Pat. 1,392,370. *J. Soc. Chem. Ind.* **40,** 804A.

Process and Apparatus for Refining Liquid Mixtures (e.g. Oil-Water Emulsions).—S. F. Alden & H. C. Eddy. H. C. Eddy, Assr. to Petroleum Rectifying Co., California. U.S. Pat. 1,394,462. *J. Soc. Chem. Ind.* **40,** 834A.

Purification of Oil and other Hydrocarbons.—M. Benson. Brit. Pat. 170,093. *J. Soc. Chem. Ind.* **40,** 838A.

Purifying Oils.—A. J. Paris. Brit. Pat. 161,253. *Chem. Abstr.* **15,** 2545.

Water-White Viscous Oils from Petroleum.—U.S. Pat. 1,388,517. *Oil, Paint, and Drug Rept.*, Petr. Section **100** (16), 21.

Natural Gas.

Natural Gas Burners Improved.—I. V. Brumbaugh & G. B. Shawn. *Gas Age* **47,** 535; **48,** 30, 73. *Chem. Abstr.* **15,** 3195.

Pressure-Volume Deviation of Methane, Ethane, Propane, and Carbon Dioxide at Elevated Pressures.—G. A. Burrell & G. W. Jones. *U.S. Bur. Mines Report Investigations,* 2276.

Well at Caldones, Asturias, The.—M. Ruys-Falco. *Bol. Inst. Geol. Espana* **37,** 3. *Chem. Abstr.* **15,** 2605.

Patents.

Apparatus for Producing Carbon from Natural Gas.—E. W. Shull. U.S. Pat. 1,375,234.

HELIUM-BEARING NATURAL GAS.—G. S. Rogers. *U.S. Geol. Surv, Prof. Paper*, 121. *J. Soc. Chem. Ind.* **40**, 846A.

MANUFACTURE OF CARBON BLACK OR OTHER SOLID REACTION PRODUCTS.—W. D. Bancroft. U.S. Pat. 1,390,480. *J. Soc. Chem. Ind.* **40**, 781A.

MANUFACTURE OF GASOLINE.—G. H. Faber, junr., Assr. to Gulf Refining Co. U.S. Pat. 1,390,472. *J. Soc. Chem. Ind.* **40**, 804A.

PETROL AND OTHER MOTOR FUELS.

ALCOHOL MOTOR SPIRIT AND POSSIBILITIES OF ITS PRODUCTION IN BRITISH GUIANA.—*U.S. Commerce Reports*, 337.

BENZINE AND MINERAL LUBRICANTS.—J. Formanek. Scott, Greenwood & Son, London.

BENZOLE FOR TRANSPORT PURPOSES.—E. de Normanville. *The Gas World*, **75**, 463.

BLENDED GASOLINE CONTAINING CASINGHEAD GASOLINE.—F. Bordas. *Ann. fals.* **13**, 539. *Chem. Abstr.* **15**, 2717.

COMBUSTION OF LIQUID FUELS IN MOTORS.—F. Wehrmann. *Z. Elektrochem.* **27**, 379. E. Terres, F. Wehrmann & Lueg. *Ibid.*, 423. *J. Soc. Chem. Ind.* **40**, 801A.

COMMERCIAL BENZINES.—A. Ganswindt. *Neueste Erfin. u. Erfahr.* **37**, 74. *Chim. et Industrie* **5**, 416. *Chem. Abstr.* **15**, 3203.

FOURTH SEMI-ANNUAL MOTOR GASOLINE SURVEY.—N. A. C. Smith. *U.S. Bur. Mines Rept. Investigations*, 2272.

HYDROGENATED COMPOUNDS AND THEIR APPLICATION AS FUELS FOR INTERNAL COMBUSTION ENGINES.—Schrauth. *Brennstoff Chem.* **2**, 184. *Chem. Abstr.* **15**, 3194.

MOTOR SPIRITS AND THEIR RELATION TO ENGINE EFFICIENCY.—J. Kewley. *Petr. Times* **6**, 750. *Oil News*, **10**, 528.

NATALITE AND THE WORLD'S MOTOR FUEL POSITION.—*Louisiana Planter* **66**, 316. *Chem. Abstr.* **15**, 2976.

NATURAL GASOLINE SPECIFICATIONS FORMULATED BY MANUFACTURERS.—*Oil Tr. J.* **12** (9), 36.

SHALE OIL GASOLINE TESTS HIGH AS MOTOR FUEL.—*Oil, Paint, and Drug Rept.*, Petr. Section **100** (19), 10.

STANDARD SPECIFICATION FOR "BENZOLE" DRAWN UP BY B.E.S.A.—*Automotor J.* **26**, 131. *Science Abstr.* **24**B, 175. *Chem. Abstr.* **15**, 2708.

UNUSUAL TYPE OF CASINGHEAD GASOLINE, AN.—C. E. Coates & B. Y. Tims. *Petr. Times*, **6**, 638.

UTILITY OF BENZOLE FOR TRANSPORT PURPOSES, THE.—E. de Normanville. Public Works, Roads, and Transport Congress. *Petr. Times* **6**, 757.

Patents.

BLENDED FUEL FROM NATURAL AND LIQUID HYDROCARBONS.—E. C. D'Yarmett. U.S. Pat. 1,376,925. *Chem. Abstr.* **15**, 2719.

LIQUID FUEL MIXTURE.—C. Le Petit. U.S. Pat. 1,377,992. *Chem. Abstr.* **15,** 3202.

METHOD OF MAKING MOTOR FUEL.—A. A. Backhaus, Assr. to U.S. Industrial Alcohol Co. U.S. Pat. 1,378,858. *J. Soc. Chem. Ind.* **40,** 804A.

MOTOR FUEL.—Chem. Fabr. Worms A.-G. Ger. Pat. 339,989. *J. Soc. Chem. Ind.* **40,** 762A.

MOTOR SPIRIT.—C. G. Sesti. Brit. Pat. 147,803. *J. Soc. Chem. Ind.* **40,** 838A.

KEROSENE.

KEROSENE MOTOR VEHICLE FUEL.—H. M. Crane. *Am. Petr. Inst. Petr. World* **19,** 11.

LUBRICANTS AND LUBRICATION.

BENZINE AND MINERAL LUBRICANTS.—J. Formanek. Scott, Greenwood & Son, London.

DIE SCHMIERMITTEL WENDUNG.—M. Winter. Verlag von Curt R. Vincentz, Hannover.

EFFECT OF CRYSTALLINE PARAFFIN WAX UPON THE VISCOSITY OF LUBRICATING OIL, THE.—E. W. Dean & L. E. Jackson. *U.S. Bur. Mines Reports Investigations,* 2249. *Chem. Abstr.* **15,** 2521.

EFFECT OF HIGH TEMPERATURES ON LUBRICATION OIL FOR CYLINDERS.—W. Ernst. *Petroleum* **17,** 1180.

FABRIKATION DER SCHMIERMITTEL.—R. Kissling & W. Hacker. Meissen i. Sa. Verlag Matthaüs Bohlmann.

FLASH-POINT OF LUBRICATING OILS, THE.—C. M. Larson. *Sci. Lubrication* **1,** (3), 14. *Chem. Abstr.* **15,** 2945.

FORMULAIRE DU GRAISSAGE INDUSTRIEL.—J. Fritsch. A. Legrand, Paris.

IMPROVEMENT OF THE LUBRICATING PROPERTIES OF MINERAL OILS, THE.—J. H. Hyde. *Engineering* **111,** 708. *Chem. Abstr.* **15,** 3161.

KEEPING LUBRICATING OIL IN GOOD CONDITION.—C. H. Bromley. *Gen. Elec. Rev.* **24,** 414. *Chem. Abstr.* **15,** 2521.

LUBRICATION AND LUBRICANTS.—L. Archbutt. *J. Soc. Chem. Ind.* **40,** 287T.

LUBRICATION OF AIR COMPRESSORS.—*Proc. Compr. Air Soc. Sci. Lubrication* **1** (4), 11. *Chem. Abstr.* **15,** 2945.

LUBRICATING OILS SUITABLE FOR USE IN DIESEL ENGINE AIR COMPRESSORS.—*Petr. World* **18,** 242. *Chem. Abstr.* **15,** 2521.

MINERAL OIL VERSUS CASTOR OIL FOR THE LUBRICATION OF INTERNAL COMBUSTION ENGINES.—W. F. Parish. *Sci. Lubrication* **1,** 7. *Chem. Abstr.* **15,** 2945.

OIL FILTRATION.—C. Wood. *Sci. Lubrication* **1** (2), 5. *Chem. Abstr.* **15,** 2982.

PROBLEMS OF LUBRICATION.—W. B. Hardy. *Proc. Roy. Inst.* (Feb. 27, 1920). *Chem. Abstr.* **15,** 3159.

RECOVERY OF LUBRICATING OIL, THE.—A. J. Wilson. *Petr. World* **18**, 29. *Chem. Abstr.* **15**, 2521.

REPORT OF THE LUBRICANTS AND LUBRICATION INQUIRY COMMITTEE.—Dept. of Scientific and Industrial Research, Advisory Council, H.M. Stationery Office, 1920. *Chem. Abstr.* **15**, 3159.

REQUIREMENTS FOR BALL-BEARING LUBRICATION.—J. B. Castino. *Sci. Lubrication* **1** (2), 18. *Chem. Abstr.* **15**, 2945.

Patents.

APPARATUS FOR WASHING AND FILTERING (USED) LUBRICATING OIL.—J. H. Packer. Brit. Pat. 169,630. *J. Soc. Chem. Ind.* **40**, 805A.

LUBRICATING OIL.—R. H. Brownlee. U.S. Pat. 1,374,277.

LUBRICANT FROM MINERAL OIL, ROSIN OIL AND MILK OF LIME.—Graf & Co. Ger. Pat. 393,905. *Oil, Paint and Drug Report.* Petr. Section **100** (9), 22.

MANUFACTURE OF LUBRICATING GREASES.—R. Maclaurin & Scottish Bye-Products, Ltd. Brit. Pat. 169,573. *J. Soc. Chem. Ind.* **40**, 804A.

PROCESS OF RECLAIMING USED LUBRICATING OILS.—W. J. Jordan, Assr. to Celite Products Co. U.S. Pat. 1,393,223. *J. Soc. Chem. Ind.* **40**, 805A.

REGENERATING USED MINERAL OILS.—French Pat. 515,138. *Oil, Paint and Drug Report.* Petr. Section **100** (16), 21.

FUEL OIL.

BURNING PETROLEUM.—E. C. Bowden-Smith. *Petr. Times* **5**, 609. *Chem. Abstr.* **15**, 2544.

DOMINICAN CENTRAL RAILWAY AND OIL FUEL.—*U.S. Commerce Report*, p. 207.

LE PÉTROLE, SON UTILISATION COMME COMBUSTIBLE.—A. Masmejean & E. Berehare. Dunod, Paris.

LIQUID FUEL AND ITS APPLICATION FOR STEAM GENERATION.—J. H. Anderson. Inst. Marine Engineers. *Petr. World* **19**, 27.

OIL FUEL IN CHILE.—*U.S. Commerce Report*, p. 207.

"ROTAMISOR" OIL-FUEL BURNER, THE.—*Engineering* **112**, 631.

Patents.

FUEL.—L. W. Bates. Brit. Pat. 161,929. *Chem. Abstr.* **15**, 2541.

FUEL, AND METHOD OF PRODUCING SAME.—L. W. Bates. U.S. Pat. 1,390,231. *J. Soc. Chem. Ind.* **40**, 761A.; also U.S. Pat. 1,390,228. *J. Soc. Chem. Ind.* **40**, 761A.

FURNACE FOR BURNING LIQUID FUELS AND PULVERULOUS COAL.—H. Horuichi. U.S. Pat. 1,390,715. *J. Soc. Chem. Ind.* **40**, 800A.

LIQUID FUEL AND METHOD OF MANUFACTURING IT.—L. W. Bates. U.S. Pat. 1,390,232. *J. Soc. Chem. Ind.* **40**, 761A.

Method of Increasing the Specific Gravity and Flash-point of (Combustible) Liquids.—L. W. Bates. U.S. Pats. 1,390,229 and 1,390,233. *J. Soc. Chem. Ind.* **40,** 761A.

Stabilised Liquid and Solid Fuel Mixture.—L. W. Bates. U.S. Pat. 1,375,811. *Chem. Abstr.* **15,** 2714.

Diesel Oil and Engines.

Characterisics of Diesel Engine Fuels.—*Sci. Lubrication* **1,** 13. *Chem. Abstr.* **15,** 2982.

Fuel and Lubricating Oils for Diesel Engines.—W. Schenker. Constable & Co., Ltd., London.

Some Recent Developments in Mechanical Injection Oil Engines Using Heavy Oils.—O. Wans, Diesel Engine Users' Association. *Petr. World* **19,** 29.

Plant and Machinery.

Density Indicator for Vacuum Stills.—*Rev. Prod. Chim.* **24,** 369. *Chem. Abstr.* **15,** 2566.

Die Wirkungsweise der Rektifizer und Destillierapparate.—E. Hausband. J. Springer, Berlin.

Solving the Problem of Oil Recovery from B.S.—R. M. Gotham. *Oil Tr. J.* **12** (9), 97.

Usefulness of Condensate Traps in Distillation Plants, The.—W Heubeling. *Chem. App.* **8,** 96. *Chem. Abstr.* **15,** 2756.

Patents.

Air-cooled Fractional Condenser for Hydrocarbon Oil Vapors.—J. W. Coast, Jr. U.S. Pat. 1,374,357. *Chem. Abstr.* **15,** 2719.

Apparatus for Condensing and Treating (Oil) Distillates.—R. Fleming, Assr. to The Richard Fleming Co. U.S. Pat. 1,394,987. *J. Soc. Chem. Ind.* **40,**, 839A.

Apparatus for Distilling Hydrocarbon Oils.—S. F. Stephens. U.S. Pat. 1,375,427. *Chem. Abstr.* **15,** 2719.

Apparatus for Treating Liquid Hydrocarbon in Distilling and Other Processes.—A. C. G. C. P. J. von Groeling, Assr. to National Refining Corp. U.S. Pat. 1,378, 066. *J. Soc. Chem. Ind.* **40,** 839A.

Condenser.—J. A. Bishop. U.S. Pat. 1,395,898. *J. Soc. Chem. Ind.* **40,** 878A.

Construction of Heat Exchangers for Use With Fluids.—Soc. Franco-Belge de Fours à Coke. Brit. Pat. 159, 489. *J. Soc. Chem. Ind.* **40,** 878A.

Continuous Fractional Distillation of Crude Oil.—E. Barbet & Sons & Co. Ger. Pat. 326,418. *Oil, Paint and Drug Report.* Petr. Section **100,** (9), 22.

Distillation of Hydrocarbon Oils, Asphalts, and the Like.—E. T. Engelke. Brit. Pat. 170,140. *J. Soc. Chem. Ind.* **40,** 839A.

DISTILLATION OF HYDROCARBON OILS, TARS, ASPHALTS, AND THE LIKE.—E. T. Engelke. Brit. Pat. 165,230. *J. Soc. Chem. Ind.* **40**, 838A.

DISTILLING HYDROCARBON OILS.—W. C. Averill, Jr. U.S. Pat. 1,375,245. *Chem. Abstr.* **15**, 2719.

DISTILLING MINERAL OILS, ETC.—*Chem. Fabriken Worms Akt. Ges.* Brit. Pat. 156,255. *Chem. Abstr.* **15**, 2715.

DISTILLING OILS.—J. G. P. Evans. Brit. Pat. 162,873. *Chem. Abstr.* **15**, 3204.

ELECTRIC HEATING APPARATUS FOR REGULATING THE TEMPERATURE IN OIL STILLS.—A. C. G. C. P. J. von Groeling. U.S. Pat. 1,378,066. *Chem. Abstr.* **15**, 3205.

FILTER FOR GASOLINE OR OTHER LIQUIDS.—H. A. Deeks. U.S. Pat. 1,376,681.

HEAT EXCHANGE APPARATUS.—J. G. McKean & R. F. Jones. Brit. Pat. 170,450. *J. Soc. Chem. Ind.* **40**, 877A.

HEATING LIQUIDS (e.g. DISTILLATION OF TAR, OILS, AND THE LIKE) BY INTRODUCTION INTO MOLTEN METAL.—Thermal Industrial and Chemical Research Co. A. M. Duckham & J. S. Morgan. Brit. Pat. 170,617. *J. Soc. Chem. Ind.* **40**, 877A.

INCLINED TUBULAR OIL STILL.—D. L. Newton & N. H. Anderson. U.S. Pat. 1,376,631. *Chem. Abstr.* **15**, 2719.

METHOD OF AND APPARATUS FOR FRACTIONAL DISTILLATION.—Thermal Industrial and Chemical (T.I.C.) Research Co., & A. McD. Duckham. Brit. Pat. 170,324. *J. Soc. Chem. Ind.* **40**, 834A.

METHODS OF OPERATING DISTILLING COLUMNS PROVIDED WITH HORIZONTAL TRAYS.—C. [Still. Ger. Pat. 335,552. *J. Soc. Chem. Ind.* **40**, 801A.

OIL-DISTILLING APPARATUS AND THE LIKE.—Whitehall Petroleum Corp., Ltd. & J. S. Smith. Brit. Pat. 165,178. *J. Soc. Chem. Ind.* **40**,, 838A.

OIL REFINING APPARATUS.—H. L. Allan. U.S. Pat. 1,390,742.

OIL STILL.—J. Primrose. U.S. Pat. 1,389,978. *J. Soc. Chem. Ind.* **40**, 762A.

PETROLEUM STILL.—A. D. Smith. U.S. Pat. 1,374,402. *Chem. Abstr.* **15**, 2719.

PROCESS OF FRACTIONALLY DISTILLING MIXTURES CONTAINING HYDROCARBONS.—E. H. French. U.S. Pat. 1,394,488. *J. Soc. Chem. Ind.* **40**, 839A.

PROCESS OF REFINING HYDROCARBONS.—C. R. Burke, Assr. to L. P. Burke. U.S. Pat. 1,389,934. *J. Soc. Chem. Ind.* **40**, 762A.

STILL.—W. D. Rial, Assr. to Marland Refining Co. U.S. Pat. 1,390,386. *J. Soc. Chem. Ind.* **40**, 800A.

VESSEL FOR BOILING AND EVAPORATING OIL, OIL-CONTAINING LIQUIDS, AND OTHER ORGANIC AND PYROGENOUSLY DECOMPOSABLE LIQUIDS.—A. J. G. J. Irinyi. Brit. Pat. 144,298. *J. Soc. Chem. Ind.* **40**, 806A.

TESTING, ANALYSIS, AND APPARATUS.

AIR-BUBBLE VISCOSIMETER.—V. R. Abrams, J. T. Cavanagh & C. H. Osmond. *Chem. and Met. Eng.* **25,** 665. *J. Soc. Chem. Ind.* **40,** 792A.

BUREAU OF MINES METHOD FOR DETERMINING WATER IN PETROLEUM.—E. W. Dean & W. A. Jacobs. *U.S. Bur. Mines Rept. Investigations,* 2159. *Chem. Abstr.* **15,** 2717.

COMPARATIVE STUDY OF FRACTIONATING STILL HEADS, A.—N. P. Moore. *J. Phys. Chem.* **25,** 273. *Chem. Abstr.* **15,** 3003.

COMPARISON OF THE METHODS OF DETERMINING WATER IN PETROLEUM, A.—J. Angli. *Anales Soc. Quim. Argentina* **8,** 105. *Chem. Abstr.* **15,** 2982.

DETERMINATION OF BENZINE IN TURPENTINE.—J. Marcusson. *Chem. Zeit.* **45,** 418. *Chem. Abstr.* **15,** 2554.

DETERMINATION OF MOISTURE IN INSULATING OILS, THE.—C. J. Rodman. *J. Ind. Eng. Chem.* **13,** 1149.

DETERMINATION OF REFRACTIVE INDICES OF OILS.—H. S. Simms. *J. Ind. Eng. Chem.* **13,** 546. *Chem. Abstr.* **15,** 2739.

DETERMINATION OF WATER IN PETROLEUM, THE.—H. Corti. *Anales Soc. Quim. Argentina* **8,** 232. *Chem. Abstr.* **15,** 2982.

DURABILITY OF ELECTRIC HEATERS FOR GASOLINE DISTILLATION.—W. A. Jacobs & E. W. Dean. *U.S. Bur. Mines Report Investigations,* 2131. *Chem. Abstr.* **15,** 2717.

EVAPORATION TEST FOR LIGHT PETROLEUM OILS.—M. Freund & G. Palik. *Petroleum* **29,** 1029. *J. Soc. Chem. Ind.* **40,** 802A.

EXAMINATION OF HYDROCARBON OILS.—G. L. Radcliffe. *J. Soc. Dyers and Colourists* **37,** 51. *Chem. Abstr.* **15,** 2543.

FLASH-POINT APPARATUS.—F. W. Shulenberger. *Paint, Oil, and Chem. Rev.* **71** (24), 9, 18. *Chem. Abstr.* **15,** 2565.

IMPROVED FORM OF REISCHAUER'S PYCNOMETER, AN.—R. Saar. *Chem. Zeit.* **45,** 102. *Chem. Abstr.* **15,** 2755.

(LABORATORY) DISTILLATION APPARATUS.—P. Gross & A. H. Wright. *J. Ind. Eng. Chem.* **13,** 701. *J. Soc. Chem. Ind.* **40,** 872A.

NEW TYPE OF CALORIMETER COMBUSTION BOMB MADE OF KRUPP'S SPECIAL STEEL.—W. A. Roth, R. Macheleidt & I. Wilms. *Z. angew. Chem.* **34,** 537. *J. Soc. Chem. Ind.* **40,** 872A.

PROPOSED A.S.T.M. DISTILLATION TEST FOR GASOLINE, KEROSENE METHODS.—*Nat. Petr. News* **13** (24), 33. *Chem. Abstr.* **15,** 2717.

TECHNICAL ANALYSIS OF PETROLEUM, THE.—I. Lazennac. *Age de Fer* **37,** 1058. *Chem. Abstr.* **15,** 2541.

TEMPERATURE CORRECTION IN BOMB CALORIMETRY.—N. H. Engström. *Tek. Tid. Kemi o. Berg.* **51,** 18. *Chem. Abstr.* **15,** 3023.

USE OF ENAMELLED BOMBS IN CALORIMETRY, THE.—C. Matignon & G. Marchal. *Compt. rend.* **172,** 921. *Chem. Abstr.* **15,** 2377.

VISCOSIMETER CALIBRATION AND CONVERSION CHART.—*Lubrication* **7** (5), 5. *Chem. Abstr.* **15,** 3004.

VISCOSITY DETERMINATIONS.—L. Fischer. *Z. angew. Chem.* **34,** 153. *Chem. Abstr.* **15,** 2367.

VOLATILITY OF INTERNAL COMBUSTION-ENGINE GASOLINE, THE.—F. A. Howard. *Sci. Lubrication* **1** (2), 14. *Chem. Abstr.* **15,** 2982.

Patent.

VISCOSIMETER.—Hadfields (Merton), Ltd., & A. E. Bawtree. Brit. Pat. 169,204. *J. Soc. Chem. Ind.* **40,** 793A.

CRACKING.

PYROLYSIS OF SOME HYDROCARBONS, THE.—F. Denig. *Chem. and Met. Eng.* **25,** 751. *J. Soc. Chem. Ind.* **40,** 802A.

Patents.

J. H. Adams. Brit. Pat. 141,689. *J. Soc. Chem. Ind.* **40,** 804A.

C. M. Alexander & G. H. Faber, jun. Assrs. to Gulf Refining Co. U.S. Pat. 1,381,098. *J. Soc. Chem. Ind.* **40,** 839A.

M. Benson. Brit. Pat. 169,763. *J. Soc. Chem. Ind.* **40,** 804A.

L. B. Cherry. Brit. Pat. 169,063. *J. Soc. Chem. Ind.* **40,** 778A. *Chem. Age* **5,** 498.

C. Cordes, Assee. of F. C. Thiele. Brit. Pat. 147,648. *J. Soc. Chem. Ind.* **40,** 804A.

C. P. Dubbs. U.S. Pat. 1,392,629. *J. Soc. Chem. Ind.* **40,** 804A.

A. B. Foster. U.S. Pat. 1,394,486. *J. Soc. Chem. Ind.* **40,** 839A.

French Pat. 517,887. *Petr. Times* **6,** 631.

F. B. Lewis & T. S. Cooke. Assrs. to Standard Oil Co. U.S. Pat. 1,392,584. *J. Soc. Chem. Ind.* **40,** 804A.

E. O. Hicks. U.S. Pat. 1,378,229. *Chem. Abstr.* **15,** 3204.

S. Löffler. Ger. Pat. 301,683. *J. Soc. Chem. Ind.* **40,** 838A.

J. R. McCabe. U.S. Pat. 1,376,713. *Chem. Abstr.* **15,** 2719.

W. M. McComb. U.S. Pat. 1,374,858. *Chem. Abstr.* **15,** 2719.

J. Nelson. U.S. Pat. 1,391,568–9.

A. J. Paris, Jun. U.S. Pat. 1,392,788. *J. Soc. Chem. Ind.* **40,** 804A.

A. Rogers. U.S. Pat. 1,378,424. *J. Soc. Chem. Ind.* **40,** 839A. *Chem. Abstr.* **15,** 3204.

R. Seeger. Assr. to New Process Oil Co. U.S. Pat. 1,394,688. *J. Soc. Chem. Ind.* **40,** 839A.

Standard Oil Co. Assees. to R. E. Humphreys. Brit. Pat. 147,715. *J. Soc. Chem. Ind.* **40,** 839A.

Standard Oil Co. Assees. of H. P. Chamberlain. Brit. Pat. 146,472. *J. Soc. Chem. Ind.* **40**, 805A.

Standard Oil Co. U.S. Pat. *Petr. Times* **6**, 770.

F. Tinker. U.S. Pat. 1,393,184. *J. Soc. Chem. Ind.* **40**, 805A.

J. A. Vielle & H. Plauson. Brit. Pat. 160,789. *Chem. Abstr.* **15**, 2541.

H. Wade. Standard Oil Co. Brit. Pat. 165,197. *J. Soc. Chem. Ind.* **40**, 805A.

F. E. Wellman. Assr. to the Kansas City Gasoline Co. U.S. Pat. 1,390,002. *J. Soc. Chem. Ind.* **40**, 762A.

E. E. Wickersham. U.S. Pat. 1,376,180.

R. Yates. U.S. Pat. 1,395,075. *J. Soc. Chem. Ind.* **40**, 839A.

W. H. Young. U.S. Pat. 1,378,307. *J. Soc. Chem. Ind.* **40**, 839A. *Chem. Abstr.* **15**, 3205.

Insulating Oils.

Transformer Oil Sludge.—C. J. Rodman. *Amer. Electrochem. Soc. Chem. and Met. Eng.* **25**, 685.

Shale and Shale Oils.

American Developments in Oil Shale Industry.—V. C. Alderson. *Petr. Times* **6**, 744.

Bituminous Schists of the Non-Valley in Trentino.—A. Coppadoro. *Giorn. Chim. Ind. Applicata* **3**, 3. *Chem. Abstr.* **15**, 2544.

Bituminous Shale (Kukersit) of Esthonia.—*Shale Rev.* **8** (4), 5. *Chem. Abstr.* **15**, 2544.

Chemical Engineering and Economics in Shale Oil Production.—A. J. Franks. *Petr. World* **19**, 12.

Colorado Shale Oils.—A. J. Franks. *Chem. and Met. Engineering* **25**, 731, 778. *J. Soc. Chem. Ind.* **40**, 836A.

Determination of the Heat of Reaction Involved in the Thermal Decomposition of Oil Shales.—R. H. McKee & E. E. Lyder. *J. Ind. Eng. Chem.* **13**, 678. *J. Soc. Chem. Ind.* **40**, 802A.

Distillation of Oil Shale.—A. H. Low. *Petr. Times* **5**, 689. *Chem. Abstr.* **15**, 2716.

Fuel Problem for Oil Shale Retorts.—G. McD. Johns. *Combustion* **5** (3), 121.

Oil Shales.—H. B. Cronshaw. J. Murray.

Oil Shale of Esthonia, The.—*Times Eng. Suppl.*, Nov., 1921. *J. Soc. Chem. Ind.* **40**, 472R.

Origin and Composition of Certain Oil Shales.—T. Thiessen. Economic Geology. *Petr. Times* **6**, 617.

PETROLEUM-BEARING SCHIST AT CHUCUMATA, CHILE.—*U.S. Commerce Report*, p. 207.

PLAUSON PROCESS OF RETORTING SHALES, THE.—(Estimate of Operating Costs.) *Petr. Times* **6,** 600.

POSSIBILITIES OF PRODUCING OIL FROM OIL SHALE.—M. J. Gavin. *U.S. Bur. Mines Report Investigations*, 2176. *Chem. Abstr.* **15,** 3203.

PRINCIPLES AND METHODS OF OIL SHALE DISTILLATION.—The Day Co., Engineers. *San Francisco Bull.* No. 3.

REPORTED DISCOVERY OF OIL SHALE IN CHILE.—*U.S. Commerce Report*, Sept. 26. *J. Soc. Chem. Ind.* **40,** 411R.

RÉSUMÉ OF THE OIL SHALE INDUSTRY, WITH AN OUTLINE OF METHODS OF DISTILLATION, A.—E. A. Trager. *Bull. Amer. Assoc. Petroleum Geolog.* **4,** 59. *Chem. Abstr.* **15,** 2716.

RETORTING PROBLEM OF COLORADO AND OTHER SHALES.—R. D. George. *Petr. Times* **6,** 687, 709.

RETORTING PROBLEM OF COLORADO SHALES.—R. D. George. *Petr. Times* **6,** 825.

SANITATION IN PLANNING AND DEVELOPING OIL SHALE CAMPS.—A. L. Murray. *U.S. Bur. Mines Reports Investigations*, 2265.

SCOTTISH SHALE OIL INDUSTRY, THE.—*Petr. Times* **6,** 616.

SELECTED BIBLIOGRAPHY ON OIL SHALE.—E. H. Burroughs & M. J. Gavin. *U.S. Bur. Mines Report Investigations*, 2277. *Chem. and Met. Eng.* **25,** 758.

SHALE INDUSTRY OF RESIUTTA, THE.—C. Guido. *Boll. chim. farm.* **59,** 245. *Chem. Abstr.* **15,** 2544.

STUDIES IN COLORADO SHALE OILS (A).—A. J. Franks. *Chem. and Met. Eng.* **25,** 731.

STUDIES IN COLORADO SHALE OILS (B).—A. J. Franks. *Chem. and Met. Eng.* **25,** 778.

THERMAL DECOMPOSITION OF OIL SHALES, THE.—R. H. McKee & E. E. Lyder. *J. Ind. Eng. Chem. Petr. Times* **6,** 631.

WORLD'S OIL SHALE FIELDS, THE. RECENT DEVELOPMENTS.—V. C. Alderson. *Petr. Times* **6,** 779, 941.

Patents.

APPARATUS FOR DEVOLATILISING SHALES, ETC.—C. M. Garland. U.S. Pat. 1,391,825. *J. Soc. Chem. Ind.* **40,** 805A.

DESTRUCTIVE DISTILLATION IN SITU.—D. Diver. Brit. Pat. 162,337. *Chem. Abstr.* **15,** 3205.

RETORT ADAPTED FOR DISTILLING SHALE, OIL-SAND, OR COAL.—A. V. Young. U.S. Pat. 1,378,643. *Chem. Abstr.* **15,** 3204.

RETORT FOR EXTRACTING OIL, ETC.—A. V. Young. U.S. Pat. 1,378,643. *J. Soc. Chem. Ind.* **40,** 839A.

LIGNITES AND COALS AND THEIR PRODUCTS.

CARBONISATION OF WESTERN LIGNITE, THE.—R. de L. French. *J. Soc. Chem. Ind.* **40**, 465R.

CARBOZIT.—H. R. Trenkler. *Feuerungstechnik* **9**, 93. *J. Soc. Chem. Ind.* **40**, 250A. *Chem. Abstr.* **15**, 2707.

CONSTITUENTS OF LIGNITES, THE.—R. Cuisa & A. Galazzi. *Univ. Bologna Gazz. Chim. Ital.* **51**, I, 55. *Chem. Abstr.* **15**, 2708.

EXTRACTION AND BRIQUETTING OF LIGNITE.—J. G. Verdier. *Rev. ing. index tech.* **27**, 343, 407; **28**, 9, 137. *Chem. Abstr.* **15**, 2538.

FUEL RESEARCH STATION AT EAST GREENWICH.—*Gas World* **75**, 3. *Gas J.* **155**, 24. *Chem. Abstr.* **15**, 2707.

GAS MANUFACTURE AND TAR RECOVERY, WITH SPECIAL REFERENCE TO THE GASIFICATION OF LIGNITES.—K. Arnemann. *Gas-u. Wasserfach* **64**, 665. *J. Soc. Chem. Ind.* **40**, 802A.

GERMAN LIGNITE INDUSTRY.—*U.S. Commerce Report*, p. 198.

LIGNITE BRICK FUEL.—*Rev. mat. constr. trav. pub.* (141), 958. *Chem. Abstr.* **15**, 2977.

LIGNITE BY-PRODUCT GAS PRODUCER, THE.—C. Bube. *Brennstoffe Chem.* **2**, 186. *Chem. Abstr.* **15**, **3198**.

LIGNITE CONTAINING COMMON SALT.—Von. Morgenstein. *Z. öffentl. Chem.* **18**, 208. *J. Soc. Chem. Ind.* **40**, 759A.

LOW-TEMPERATURE CARBONISATION.—D. Brownlie. *Chem. Tr. J.* **69**, 523.

LOW-TEMPERATURE CARBONISATION.—*Chem. Tr. J.* **69**, 594.

LOW-TEMPERATURE CARBONISATION AND SMOKELESS FUEL.—H. E. Armstrong. *J. Roy. Soc. Arts* **69**, 385. *Chem. Abstr.* **15**, 2537.

LOW-TEMPERATURE CARBONISATION OF COAL.—W. A. Bone. *Gas J.* **155**, 31. *Engineering* **112**, 68. *Chem. Abstr.* **15**, 2707.

MACLAURIN CARBONISATION PROCESS.—*Iron and Coal Trades Rev.* **102**, 848. *Chem. Abstr.* **15**, 2713.

NEW SALEM LIGNITE FIELD, MORTON COUNTY, NORTH DAKOTA.—E. T. Hancock. *U.S. Geol. Surv. Bull.* 726A. *Chem. Abstr.* **15**, 2604.

NITRATION OF LIGNITE.—J. Marcusson. *Z. angew. Chem.* **34**, 521. *J. Soc. Chem. Ind.* **40**, 835A.

OXIDATION OF COAL AND OTHER SOLID FUELS UNDER PRESSURE.—F. Fischer & H. Schrader. *Ges. Abhandl. Kennt. Kohle* **4**, 342. *Chem. Abstr.* **15**, 2706.

OXIDATION OF LOW-TEMPERATURE COAL TAR AND ITS FRACTIONS UNDER PRESSURE.—F. Fischer & U. Ehrhardt. *Ges. Abhandl. Kennt. Kohle* **4**, 280. *Chem. Abstr.* **15**, 2713.

PRESENT STATUS OF COAL CARBONISATION AT LOW TEMPERATURE.—J. D. Davis. *Gas World* **75**, 495.

PRESSURE OXIDATION OF MONTAN WAX.—F. Fischer & W. Schneider. *Ges. Abhandl. Kennt. Kohle* **4**, 180. *Chem Abstr.* **15**, 2737.

PRODUCTION OF OILS BY HYDROGENATION OF COAL, THE. I.—The Hydrogenation of coal and other solid fuels by means of sodium formate.—F. Fischer & H. Schrader. *Brennstoffe Chem.* **2**, 161. *Chem. Abstr.* **15**, 3193.

RESEARCHES UPON BROWN COALS AND LIGNITES. I.—Heat treatment at temperature below 400° as a possible method of enhancing their fuel values.—W. A. Bone. *Proc. Roy. Soc.* **99A**, 236. *Chem. Abstr.* **15**, 2977.

REVOLVING RETORT, THE: ITS PRESENT STATUS AND TECHNICAL AND ECONOMIC POSSIBILITIES.—M. Dolch. *Montan Rundschau* **13**, 117, 133, 150. *Chem. Abstr.* **15**, 2980.

SOME CRETACEOUS LIGNITES AT PORTABRURIO, TERUEL. *M.F. y Sans. Bol. Soc. Espan. Hist. Nat.* **20** (7), 68. *Rev. Géol.* **1**, 482. *Chem. Abstr.* **15**, 2812.

Patents.

ARTIFICIAL FUEL.—F. F. Fournier. Brit. Pat. 163,042. *Chem. Abstr.* **15**, 3202.

DRYING AND CARBONISATION OF LIGNITE AND THE LIKE FOR THE PRODUCTION OF A TAR RICH IN UNDECOMPOSED BITUMEN.—F. Seidenschur. Brit. Pat. 169,847. *Chem. Ind.* **40**, 803A.

LOW-TEMPERATURE CARBONISATION AND GASIFICATION OF COAL AND OTHER CARBONACEOUS MATERIAL.—C. W. Tozer. Brit. Pat. 169,580. *J. Soc. Chem. Ind.* **40**, 805A.

MANUFACTURE OF LIQUID ORGANIC COMPOUNDS FROM COAL.—F. Bergius. Brit. Pat. 148,436. *J. Soc. Chem. Ind.* **40**, 838A.

PARAFFIN WAX, LUBRICATING OILS.—E. Erdmann. Brit. Pat. 156,694. *Chem. Abstr.* **15**, 2720.

PRELIMINARY TREATMENT OF LIGNITE, EARTHY LIGNITE, PEAT AND SIMILAR SUBSTANCES, BEFORE DEHYDRATION.—Rabbas, Willink und Co. Ger. Pat. 339,254. *J. Soc. Chem. Ind.* **40**, 761A.

PROCESS FOR OBTAINING VISCOUS LUBRICATING OILS OF HIGH FLASHING-POINT FROM BITUMINOUS MATERIALS.—Deutsche Erdöl A.G. F. Seidenschur & C. Koettnitz. Ger. Pat. 307,166. *J. Soc. Chem. Ind.* **40**, 839A.

PITCH, ASPHALT AND BITUMEN.

ASPHALT AND RELATED BITUMENS IN 1919.—K. W. Cottrell. U.S. Geol. Surv. *Mineral Resources of U.S.*, 1919, Part II, 279. *Chem. Abstr.* **15**, 2982.

ASPHALT AND RELATED BITUMENS IN 1920.—K. W. Cottrell. U.S. Geol. Surv.

ASPHALT INDUSTRY, THE.—P. Hubbard. *Commercial America. Chem. Tr. J.* **69**, 656.

DIE NATURLICHEN UND KÜNSTLICHEN ASPHALTE.—J. Marcusson. E. Engelmann, Leipzig.

RELATIONS BETWEEN THE FAT AND ASPHALT INDUSTRIES.—J. Marcusson. *Z. deut. Oel-Fett Ind.* **41**, 225. *Chem. Abstr.* **15**, 2557.

TAR-SANDS IN ALBERTA.—*J. Soc. Chem. Ind*, **40**, 406R, 469R.

Patents.

Apparatus for Melting and Handling Asphalt.—M. P. Wall. U.S. Pat. 1,378,637. *Chem. Abstr.* **15,** 3205.

Forming Asphalt from Petroleum Residue.—V. C. Illing & J. Kelly. Brit. Pat. 163,656. *J. Ind. Eng. Chem.* **25,** 715.

Process for Manufacturing Lubricating Oils from Asphaltic Materials.—Deutsche Erdöl A.G. F. Seidenschur & C. Keottnitz. Ger. Pat. 305,105. *J. Soc. Chem. Ind.* **40,** 839A.

Paraffin, Ozokerite and Vaseline.

Rate of Solidification of Paraffins.—H. Fricke. *Chem. Zeit.* **45,** 891. *J. Soc. Chem. Ind.* **40,** 761A.

Origin of Petroleum.

Formation of Petroleum from Fish Oils. Origin of Japanese Petroleum.—K. Kobayashi. *J. Chem. Ind. Japan* **24,** 1. *J. Soc. Chem. Ind.* **15,** 2542.

Origin of Oil.—H. W. Hixon. *Oil and Gas J.* **20** (3), 76. *Chem. Abstr.* **15,** 2604.

Origin of the Argentine Petroleum Deposits.—G. Bonarelli. *Anales Soc. Quim. Argentina* **7,** 412. *Chem. Abstr.* **15,** 2812.

Story of Petroleum, The. Pictures from the Past History of Our Planet.—E. Blumer. *Neujahrsbl. naturf. Ges. Zurich,* 1920, 1. *Rev. géol.* **1,** 356. *Chem. Abstr.* **15,** 2812.

Theory on the Origin of Hydrocarbons.—H. L. Fairchild. *Oil and Gas J.* **19** (51), 70. *Chem. Abstr.* **15,** 2404.

Physical Properties of Petroleum and Its Products.

Common Characteristics of Crude Petroleum Emulsions.—E. E. Ayres, Jr. *J. Ind. Eng. Chem.* **13,** 1011.

Emulsifying Agents in Oil-Field Emulsions.—J. L. Sherrick. *J. Ind. Eng. Chem.* **13,** 1010.

Emulsions with Finely Divided Solids.—T. R. Briggs. *J. Ind. Eng. Chem.* **13,** 1008.

Heat Transmission by Liquids and Gases as a Function of the Velocity.—H. Preuszler. *Stahl u. Eisen* **41,** 827. *Chem. Abstr.* **15,** 2945.

Some Factors Affecting the Stability and Inversion of Oil-water Emulsions.—L. W. Parsons & O. G. Wilson, Jr. *J. Ind. Eng. Chem.* **13,** 1116.

Some Physical Properties of Hydrocarbons Containing Two and Three Carbon Atoms.—O. Maass & C. H. Wright. *J. Amer. Chem. Soc.* **43,** 1098. *Chem. Abstr.* **15,** 2369.

Specific Dispersion of Hydrocarbons, The.—E. Darmois. *Compt. Rend.* **172,** 1102. *Chem. Abstr.* **15,** 2570.

Temperature Variation of Viscosity of Lubricants.—L. Gümbel. *Z. tech. Physik* **1,** 47. *Science Abstr.* **24B,** 112. *Chem. Abstr.* **15,** 2681.

Chemistry of Petroleum.

Action of Anhydrous Stannic Chloride on Petroleum and its Distillates.—G. Torossian. *J. Ind. Eng. Chem.* **13,** 903. *J. Soc. Chem. Ind.* **40,** 802A.

Action of Oxidising Agents on Vaseline and Paraffins.—A. Langer. *Chem. Zeit.* **45,** 466. *Chem. Abstr.* **15,** 2717.

Action of Selenium on High-boiling Mineral Oils.—K. Graefe. *Z. angew. Chem.* **34,** 509. *J. Soc. Chem. Ind.* **40,** 803A.

After-treatment of Solution Obtained in Pressure Oxidation of Paraffin Wax.—F. Fischer & W. Schneider. *Ges. Abhandl. Kennt. Kohle* **4,** 94. *Chem. Abstr.* **15,** 2737.

By-products of the Pressure Oxidation of Paraffin Wax.—W. Schneider. *Ges. Abhandl. Kennt. Kohle* **4,** 101. *Chem. Abstr.* **15,** 2736.

Chemistry of Oil.—W. F. Parish. *Sci. Lubrication* **1** (3), 30. *Chem. Abstr.* **15,** 2945.

Chlorination of Methane in Stages and the Valence Energy in the Chloromethanes, The.—F. Martin & O. Fuchs. *Z. Elektrochem.* **27,** 150. *Chem. Abstr.* **15,** 2375.

Importance of the Olefine Gases and their Derivatives. I. *Sources and Uses of Ethylene and Propylene.*—G. O. Curme, Jun. *Chem. and Met. Eng.* **25,** 907.

Importance of the Olefine Gases and their Derivatives. II. *Diethyl Sulphate.*—G. O. Curme, Jun., & H. R. Curme. *Chem. and Met. Eng.* **25,** 957.

Influence of Various Factors During the Pressure Oxidation of Paraffin Wax.—F. Fischer & W. Schneider. *Ges. Abhandl. Kennt. Kohle* **4,** 48. *Chem. Abstr.* **15,** 2736.

Iodine Numbers of Unsaturated Hydrocarbons and Cracked Gasolines, The.—W. F. Faragher, W. A. Gruse & F. H. Garner. *J. Ind. Eng. Chem.* **13,** 1044.

Oxidation of Paraffin Wax by Air at Ordinary Pressure.—W Schneider. *Ges. Abhandl. Kennt. Kohle* **4,** 132. *Chem. Abstr.* **15,** 2737.

Pressure Oxidation of Paraffin Wax.—F. Fischer. *Ges. Abhandl. Kennt. Kohle* **4,** 35. *Chem. Abstr.* **15,** 2736.

Some Chemical Considerations of Petroleum Refining.—B. T. Brooks. *Chem. and Met. Eng.* **24,** 1022. *Chem. Abstr.* **15,** 2981.

Treatment of the Acids Obtained in the Pressure Oxidation of Paraffin Wax.—W. Schneider & O. Jantsch. *Ges. Abhandl. Kennt. Kohle* **4,** 118. *Chem. Abstr.* **15,** 2736.

Patents.

Acetylating Chlorohydrocarbons.—G. T. Koch & A. L. Stallkamp. U.S. Pat. 1,374,666. *Chem. Abstr.* **15,** 2641.

Art of Chlorination (Preparation of Chloropropanes).—H. E. Buc, Assr. to Standard Oil Co. U.S. Pat. 1,391,758. *J. Soc. Chem. Ind.* **40,** 827A.

Process for Producing Olefines.—H. F. Saunders, Assr. to the Glysyn Corp. U.S. Pats. 1,393,248 and 1,393,249. *J. Soc. Chem. Ind.* **40,** 827A.

Process of Chlorination (of Hydrocarbons).—F. Sparre & W. E. Masland. Assr. to E.I. du Pont de Nemours & Co. U.S. Pat. 1,379,367. *J. Soc. Chem. Ind.* **40,** 827A.

Production of Pentachloroacetone.—H. E. Buc, Assr. to Standard Oil Co. U.S. Pat. 1,391,757. *J. Soc. Chem. Ind.* **40,** 827A.

Synthetically Produced Hydrocarbon Oils.—R. H. Brownlee. Brit. Pat. 161,175. *J. Soc. Chem. Ind.* **40,** 805A.

Oil Gas and Petrol Gas.

Patent.

Preventing Deposition of Carbon in Hydrocarbon Vapour Generators.—J. R. Kendall. U.S. Pat. 1,376,100. *Chem. Abstr.* **15,** 2719.

Miscellaneous.

Combustibles Industriels.—F. Colomer & C. Lordier. Dunod, Paris.

De l'Emploi des Combustibles Liquides.—Librairie Desforges, 29 Quai des Grands Augustens, Paris.

Fuel-Oil Stations in the Azores.—*U.S. Commerce Reports*, p. 408.

Fuel Problems of the Future.—Sir G. Beilby. *Gas J.* **154,** 737. *Iron and Coal Trades Rev.* **103,** 1. *Engineering* **112,** 26. *Gas World* **75,** 6. *Engineer* **132,** 20. *Chem. Abstr.* **15,** 2705.

Government and Free Competition.—E. P. Parker. Amer. Petr. Institute. *Petr. World* **19,** 10.

International Petroleum Institute, An.—E. Schmitz. Société de Chimie Industriale, Paris. *Petr. Times* **6,** 689.

Leading Oilmen Review Oil Affairs.—W. C. Teagle, E. L. Doheny & L. C. Sands. *Oil News* **10** (No. 472 Supplement).

Looking Ahead.—H. F. Sinclair. Amer. Petr. Institute. *Petr. World* **19,** 9.

Oil Refineries in the United States.—*Petr. Times* **6,** 937.

Oil Trade Calculator.—T. H. Butler. Scott, Greenwood & Son (London).

Petroleum.—Sir Boverton Redwood. 4th Ed. C. Griffin & Co., Ltd.

Recent Articles on Petroleum and Allied Substances.—E. H. Burroughs. *U.S. Bur. Mines Report Investigations*, 2271.

Relation of Supplies to the Petroleum Industry.—L. C. Sands. Amer. Petr. Institute. *Petr. Times* **6,** 863. *Oil News* **10** (No. 472 Supplement).

Science's Future with Oil.—A. D. Little & E. E. Wilson. *Petr. Age* **8** (14), 16 (15), 86.

World's Production in 1930.—U.S. Geol. Surv. *Oil News* **10,** 551.

Abstracts.

Compiled by F. G. P. Remfry, B.A., D.Sc., A.I.C.

Report on the Industrial, Commercial and Economic Situation in Poland, dated March, 1921.—R. E. Krineus, Commercial Secretary to H.M. Legation, Warsaw.

Inter alia, Ozokerite production has fallen, only one company now operating. Petroleum production is the chief industry of Galician Poland; there are 578 wells, 29 refineries, and 34 operating companies.

Conveyance of Highly Inflammable Liquids.—J. Muchka. E.P. 148,171.

Direct Fired Oil-fuel Furnaces.—C. F. Priest. E.P. 164,837 of 13/3/20.

Sulphur Recovery and Gas Purification.—A. Engelhardt. *Z. angew. Chem.*, 1921, **34**, 293–5.

Activated charcoal, prepared from wood by dry distillation in presence of salts, particularly chlorides of ammonium, zinc, aluminium, and iron, or by treatment with superheated steam at 1000° C., absorbs twice its own weight of hydrogen sulphide from gases containing 6 gms. per cub. m., and more under cold and pressure.

The gas, mixed with a little oxygen and ammonia, is passed over the charcoal. Rapid oxidation produces a deposit of sulphur in the pores of the latter from which it is recovered by extraction with a solvent. Reaction temperature about 60° C. The charcoal can be recovered.

Shale Oil. Composition of Swedish.—G. Hellsing. *Ark. Kemi. Min. Geol.*, 1920, **7**, No. 29, 1–23.

By dry distillation the oil obtained was poorer in paraffin and richer in aromatic hydrocarbons than Scottish and French shale oils.

Toluene, ρ-xylene, ψ-cumene, a trimethyl benzene, and durene were identified, also traces of naphthalene.

These aromatic constituents are regarded as primary and not secondary products of the distillation. The resistant hydrocarbons probably consist chiefly of naphthenes.

Treatment of Heavy Oils.—A. E. Dunstan & F. B. Thole. E.P. 156,284.

Heavy residual oils containing amorphous solid hydrocarbons are transformed into limpid fuel oils by heating under pressure; for example, 400° C. at 200 lbs., whereby the aforesaid hydrocarbons are decomposed.

Treatment of Petroleum. J. W. Lewis. U.S. Pat. 1,364,443.

Oil is cracked at a pressure higher than atmospheric. The pressure of the vapours is then lowered, but still kept above atmospheric, and condensation effected during this stage.

Treatment of Hydrocarbons.—W. F. Rittman & C. B. Dutton. U.S. Pats. 1,365,602–5.

(A) Vapour phase cracking is carried out by discharging oil through an inner tube against the upper end of a vertical retort, which part is

kept above the vaporizing temperature of the oil. The products are withdrawn from the annular space.

(B) Continuous treatment of oil in an apparatus providing sufficient heat both to crack oil vapours and preheat the incoming oil.

(C) A high boiling-point oil is vaporised and cracked, the desired low boiling-fraction separated and the high boiling residue recracked.

(D) Hydrocarbons are subjected to heat and pressure to produce predominant quantities boiling below 30° C. The naphtha is condensed and used for scrubbing the uncondensed vapours.

DISTILLING PETROLEUM OILS.—F. A. Kormann. E.P. 164,529.

Porous material preferably made of clay and cork flour bricks, and superheated steam may be used to assist the process.

REMOVING RESIDUAL MATTER FROM CRACKING STILLS.—J. W. Coast, jr. U.S. Pat. 1,379,333.

After removing the liquid residue from the cylindrical cracking still, the coke is swept backwards and forwards across the bottom and at the same time dried, and can be readily removed.

APPARATUS FOR DISTILLATION.—C. A. Nottingham & C. Tukey. U.S. Pat. 1,379,876.

Superimposed horizontal retorts are so connected that the material traverses a zigzag path therein by means of conveyors and is subjected to gradually increasing temperature.

CHLORINATING PARAFFIN HYDROCARBONS.—G. T. Koch & A. L. Stallkamp. U.S. Pat. 1,380,067.

A finely divided catalyst is suspended in the liquid hydrocarbon and chlorine passed in from below.

GENERAL REPORT ON ECONOMIC SITUATION IN SWITZERLAND, April, 1921.—J. R. Cahill.

Inter alia, a concession extending over 12,000 acres in the Canton of Geneva for the exploitation of oil sands has been taken up by an Anglo-Swiss company.

The oil yield is estimated to be 20 gallons per ton of bituminous sandstone, and a plant is being erected to treat 200 tons daily.

FILTER PLATES.—F. Krupp & P. L. Fauth. E.P. 156,739.

The openings in the plates through which passes the expressed liquid are provided with baffles in the form of ledges which are said to reduce the tendency to clogging.

CONDENSERS, DEPHLEGMATOR, AND COLUMN STILLS.—R. P. Douglas. E.P. 164,793.

A device by which the amount of cooling surface in the column may be regulated. The column is formed with deep circular indentations, on which rest plates with serrated edges that taper from the centre to the circumference. To provide maximum contact of the liquid with the walls circular grooves or ridges are provided near the edges on the under sides of the plates, causing the liquid to fall on the indentation of the column. For minimum contact the grooves or ridges on the plates

are dispensed with and placed on the under side of the indentations of the column, causing the liquid to fall on the plates and flow over both sides of them.

RE-RUN STILL.—D. Pyzel. U.S. Pat. 1,383,024.

A device for utilising the heat from a still residue to distil off light fractions from other oils. An inclined cylindrical still is divided into three transverse sections, the two end ones being connected in their lower halves by tubes, while the centre one has the upper part divided by partitions. Hot residuum is delivered into the higher end space of the still and flows through the pipes to the lower end, the oil to be distilled being in centre space and heated by the tubes. Vapours are withdrawn separately from the compartments bounded by the partitions.

DISTILLATION.—Farbenfabriken vorm F. Bayer u. Co. G.P. 334,669.

The tube leading off the vapours from a still is made with double walls filled with insulating material, thus preventing loss of heat.

HYDROGENATION OF MINERAL OIL AND COAL.—F. Bergius. *Z. angew. Chem.*, 1921, **34**, 341–7.

When heated with hydrogen at 400° C. under 100 atm. pressure, heavy mineral oils are transformed into low-boiling products. The preliminary experiments were carried out in a 5 l. gas-fired rotating autoclave, and a continuous method of working is described.

The author compares the products and yields with those obtained by cracking, the chief advantage lying in the absence of coke formation and the much smaller production of uncondensable gases. Coal treated in the same way gives a greatly increased yield of oil.

CONSTITUENTS OF BITUMINOUS LIGNITE FROM WHICH TAR IS DERIVED.—E. Erdmann. *Z. angew. Chem.*, 1921, **34**, 309–14.

The author makes four classes of constituents: (1) bitumen, soluble in benzol; (2) organic constituents termed "Restkohle," insoluble in the usual solvents; (3) humic acids, soluble in hot soda; and (4) inorganic matter. Moisture is disregarded. A certain lignite contained 18·1% of bitumen, 38·6% "Restkohle," and 43·3% humic acid by weight, yielding respectively 11·96, 12·8, and 3·55% of tar, the paraffins in which are mainly produced by the bitumen. The author agrees with Fischer (*J.S.C.I.*, 1921, 172A) that the humic acids in lignite are derived from lignin, but criticises his assumption that the cellulose of the original plant matter had no influence in the formation of coal.

CONSTITUTION OF FOSSIL RESINS.—C. Engler & J. Tausz. *Z. angew. Chem.*, 1921, **34**, 308–9.

The formation of fossil resins such as amber, coal bitumen, and oil shale are said to be due to a long chemical process accompanied by polymerisation. Shale heated to 270° C. with benzol under pressure gives the same yield of tar as when first heated to 270° C. and then extracted with boiling benzol under ordinary pressure, but if the preliminary heating is omitted the yield of tar extracted is greatly diminished. This is said to prove depolymerisation at 270° C.

Vaporization of Paraffin Oil in Coal Gas.—N. Swindin. *Gas J.*, 1921, **155**, 266–9.

Dry commercial kerosine has a vapour pressure ranging from 0·97 in. of mercury at 15° C. to 1·72 in. at 65° C. Moisture hinders vaporisation. Thus 1,000,000 cub. ft. of dry coal gas absorb 18 galls. of oil, without subsequent deposition, at 15·5° C., but undried gas only 4 galls. In still air the rate of vaporisation—in kg. per sq. m. per hr.—is 0·09 at 39° C. and 8·77 at 115° C. A vaporisation apparatus described in *J.S.C.I.*, 1917, 998, was found very efficient.

Colorado Shale Oils.—A. J. Franks. *Chem. and Inst. Eng.*, 1921, **25**, 49–53.

The distribution of sulphur and nitrogen in the different 10% distillation fractions (cf. *J.S.C.I.*, 1921, 336A) was examined. The sulphur was found to vary only slightly with all oils, but was slightly less in the light and heavy fractions. The constancy of the amount in the middle oils points to the presence of a series of isomers, whilst a different series of compounds probably exist in light and heavy fractions respectively. A modified method of estimating sulphur, using sodium peroxide, potassium chlorate, and benzoic acid in a Parr bomb, was found preferable to the usual methods, and in the absence of a bomb Water's nitric acid method (*J.S.C.I.*, 1920, 438A) was recommended. More nitrogen is present than in most petroleums, but on distillation about 40% is lost, pointing to the presence of unstable nitrogenous compounds in the lower fractions of the crude oil since those boiling above 225° C. contain a higher percentage of nitrogen. The saturated oils are said to be formed during distillation by decomposition of unsaturated compounds of high molecular weight containing both nitrogen and sulphur.

Colloidal Fuel.—L. W. Bates. E.P. 149,306.

Solid, finely ground carbonaceous matter, 85% of which will pass through a 200-mesh screen, is suspended in fuel oil, the mixture being heavier than water. A stable suspension is obtained by the use of two or more of the following: a protective agent, a peptiser, a buoyant solid, an immisable or only slightly misable liquid, adjustment of viscosity or grinding the solid in presence of the oil.

Agitation and heat treatment are employed.

Obtaining Volatile Fractions from Crude Oils.—E. F. Engelke. E.P. 164,800.

Crude mineral oils, coal tar, or similar hydrocarbons are injected by means of heated gases containing hydrogen, with or without superheated steam, into an expansion chamber from which the evaporated portions are drawn off to condensers. The residue is twice retreated and may then be similarly treated at higher temperatures.

Distillation and Cracking of Hydrocarbons.—N. V. S. Knibbs. E.P. 165,863.

The apparatus consists of a vertical cylinder containing refractory material. Oil is sprayed in at the top and air introduced at the bottom. Complete combustion is effected until the refractory material is heated,

the oil supply being then increased so that only a portion is burnt whilst the rest is distilled or cracked by the hot combustion gases. The temperature is regulated by the supply of air or the introduction of steam or water. For cracking a pressure of 50–500 lb. is maintained in the cylinder.

MANUFACTURE OF LUBRICATING OILS. J. E. Southcombe & H. M. Wells. E.P. 165,897.

After treating in the usual way with sulphuric acid the oil is washed with water only until 1 to 3% of organic acids—particularly sulphonic acids—remain. Or an oil containing 1 to 3% of glycerides may be treated with steam to hydrolise the latter to fatty acids.

DISTILLATION OF PETROLEUM.—E. O. Hicks. U.S. Pat. 1,378,229.

The distillation of the liquid portions of petroleum boiling above 260° C. is carried out in a still in which the condensates are led back into small stills contained within the large one, which is heated to 340°–450° C., and are thus revaporised. By this means preservation of viscosity is claimed. A pressure of 4–5 atm., is maintained during distillation and condensation. The accumulation of gas from the condensates is released from time to time.

PURIFICATION OF CRUDE PETROLEUM.—J. W. Bostick & C. H. Homer. U.S. Pat. 1,380,863.

Impurities in the oil are made to settle by heating the upper layer only as it flows slowly through a series of shallow tanks, the discharge from each tank being at the surface of the oil. The vapours generated are removed and condensed.

DEHYDRATOR FOR PETROLEUM OILS.—H. R. Quinby. U.S. Pat. 1,381,234.

The device consists of an outer electrode formed by a pair of concentric metallic walls and an inner cylindrical electrode arranged in the annular space of the outer electrode, into which space the oil is passed for treatment. The electrodes are movable relative to each other.

CONCURRENT CRACKING AND DISTILLATION OF PETROLEUM.—D. W. Hoge. U.S. Pat. 1,382,727.

After removal of petrol by distillation from crude petroleum the subsequent vapours are forced into a cracking plant and the hot cracked vapours passed through petroleum still containing petrol. The latter is thus distilled off together with the cracked vapours and condensed and the residue transferred to the still.

SUBSTITUTE FOR BONE CHARCOAL IN OIL REFINING.—Rekord-Zement-End. G.P. 337,060.

A suitable product is made from bituminous shale, or the residue from its distillation, by heating and subsequent cooling in the absence of air.

ESTIMATION OF SULPHUR IN OILS.—E. Hauser. *Anal. Fis. Quim.*, 1921, **19**, 175–91.

The substance is ignited by means of an electric coil and burnt in a closed vessel filled with oxygen. After cooling a dilute solution of sodium peroxide is introduced and the contents washed out. A little bromine water is added and the sulphur estimated as sulphate.

WATER RESISTANT PAINT.—Plönnis & Co. G.P. 337,189 (addn. to 301,783).

By adding petroleum oil to the mixture specified in the chief patent the resulting paint is brighter in tone and suitable for optical signals.

RECOVERY OF VOLATILE SOLVENTS BY BAYER PROCESS.—H. Caisteus. *Z. angew. Chem.*, 1921, **34**, 389–92.

The process (G.P. 310,092. *J.S.C.I.*, 1921, 204A) consists of absorbing the vapours in activated charcoal and subsequent recovery by treatment with steam and condensation. It is claimed to be the only one giving complete extraction of benzene hydrocarbons from coal gas and works effectively with such low-boiling liquids as methyl chloride. Working costs and depreciation are low.

CONDENSERS AND COOLERS.—R. Rau. E.P. 144,739.

A cooling coil is attached at both ends to a hollow axle capable of rotating the whole inside a fixed casing, through which circulates the cooling medium. The hollow axle is divided longitudinally into two compartments of unequal size, with a single entrance at different ends.

The material to be cooled enters the coils through the larger compartment and leaves through the smaller.

USE OF OIL IN CLEANING COAL.—G. St. J. Perrott & S. P. Kinney. *Chem. and Met. Eng.*, 1921, **25**, 182–8.

Low grade coal or coal refuse, pulverised to pass 200 mesh, is agitated with a mixture of oil and water, coaly matter being entrapped whilst mineral matter falls to the bottom.

Any oil, provided that the viscosity is not too great, may be used, but the best conditions for rapid separation exist when the surface tension between coal and oil is low and high between coal and water, and oil and water. The quantity of oil necessary is about 30% of the weight of the coal.

DETERMINATION OF WATER IN TRANSFORMER OILS.—E. Rengade & J. Clostré. *Comptes rend.*, 1921, **173**, 311–13.

Twenty l. per hour of perfectly dry air are first passed through 200 cc. of oil heated to 80° C. and then through a U-tube cooled by liquid air or solid carbon dioxide. Every 15 minutes the tube is changed and weighed and the condensate examined for (1) water by ability to freeze at 0° C., action on anhydrous copper sulphate or lead potassium iodide, and for (2) oil by its inability to freeze at 0° C. and its inflammability.

COLLOIDAL FUEL.—L. W. Bates. E.P. 165,418–23 and 165,425. An amplification of E.P. 149,306.

GREASE FOR THE PREPARATION OF COLLOIDAL FUEL.—L. W. Bates. E.P. 165,424.

Slaked lime is mixed with a hydrocarbon oil, which is then agitated and heated. Resin is next added and the product saponified. The oil should have an open cup flash-point of at least 120° C., and a viscosity of 20° Engler at 20° C. and 10° Engler at 30° C.

RECOVERY OF VOLATILE HYDROCARBONS.—*Allgem. Vergasungs-Ges.* G.P. 337,054.

A device for the continuous recovery of liquifiable hydrocarbons from

gases, such as petrol from natural gas by cooling the latter and passing it through a "disintegrator," which also may be cooled internally.

PRODUCTION AND PURIFICATION OF PARAFFIN WAX.—*Allgem. Ges. für Chem. Ind.* G.P. 337,512.

The required fraction of tar or oil is first treated with liquid sulphur dioxide according to the original patent (G.P. 310,653. *J.S.C.I.*, 1920, 327A), and the solid paraffin wax thus obtained is treated by allowing liquid sulphur dioxide to flow over the surface. By this means adherent oily matter is removed without the need of filtration.

MANUFACTURE OF LUBRICATING OILS.—R. H. Brownlee. E.P. 141,753. (See U.S. Pat. 1,309,432 of 1919.)

By the use of a catalyst, such as aluminium chloride, the polymerisation of unsaturated hydrocarbons is accelerated. The lighter compounds are then distilled off.

PRODUCTION OF ACTIVATED CARBONACEOUS MATERIAL.—E. R. Sutcliffe. E.P. 166,202.

Finely divided coal is mixed with activated material from a previous operation and after briquetting and coking is activated by means of steam at 1000° C. or any other method for activating charcoal.

PURIFICATION OF TAR LUBRICATING OILS.—A. G. Rütgerswerke & H. Mallison. G.P. 337,091.

By treating the filtered oils with superheated steam at a temperature below their boiling-point until all acridine-like odours disappear.

OILYNESS OF FATTY AND MINERAL LUBRICANTS.—P. Woog. *Comptes rend.*, 1921, **173**, 303–6.

The mean molecular volume of a number of lubricants was determined, cryoscopically, at different concentrations, from which was calculated the molecular weight in an infinitely dilute solution. The mean molecular volume of a fatty oil was found to be much greater than that of a mineral oil of the same viscosity.

WATER SOLUBLE OILS.—*Badische Anilin-und Soda-Fabrik.* G.P. 336,558.

Propylated aromatic sulphonic acids, made from isopropyl alcohol and aromatic sulphonic acids in the presence of sulphuric acid form consistent emulsions with petroleum oils, benzene, etc., which do not separate on diluting with water.

MANUFACTURE OF ALDEHYDES AND ALDEHYDE-FATTY ACIDS FROM MINERAL OILS.—C. P. Byrnes. E.P. 138,113.

By passing a mixture of mineral oil vapour and air, with or without steam, over a catalyst heated to 230°–500° C.

Suitable catalysts are the oxides of one or more metals of variable valency such as the blue oxides of molybdenum—containing MoO_2, MoO_3—uranyl vanadate VO_2, V_2O_4, etc. A Pennsylvanian petroleum distillate—90% boiling between 250°–340° C.—with oxides of molybdenum on asbestos as catalyst heated to 310–20° C. gave a yield of 74% of products of which 27·2% were aldehydes and 66% aldehyde-fatty acids.

Detection of Nitrogen in Organic Compounds.—C. D. Zenghelis. *Comptes rend.*, 1921, **173**, 308–10.

The method is applicable to all classes of organic nitrogenous compounds, of which only a very small amount is required and is very rapid and sensitive.

The substance is mixed in a crucible with a mixture of soda lime and copper powder (2 : 1), and above this is put more of the soda-copper mixture. The crucible is covered with a watch glass, on the under side of which is suspended a drop of formalin-silver nitrate reagent for detecting ammonia (*J.S.C.I.*, 1921, 581A), and on top some cold water. Heat the crucible on a hot plate until drops of moisture start condensing on the watch glass and then place aside to cool. The presence of nitrogen is indicated by the formation of a silver mirror.

Report of the Trade, Industry, and Finance of Morocco. Dated May, 1921. H.M. Department of Overseas trade.

Inter alia, numerous permits have been issued for oil prospecting between Gibel Tselfats, and Fez and Taza, and two for exploitation. A deposit of bituminous schist has also been discovered near Tangiers, and is to be worked by an Anglo-French company.

Report on Economic and Industrial Conditions in the Serb-Croat-Slovene Kingdom. Dated April, 1921.—E. M. Harvey, H.M. Legation, Belgrade.

Inter alia, prospecting for petroleum is taking place in the Belovar, Virovitica, and Darovar districts, but so far only natural gas has been struck.

Influence of Drying on the Yield of Tar from Lignite.—F. Seidenschnur. *Brennstoff-Chem.*, 1921, **2**, 241–4.

Two lignites containing 37·5% and 54·8% of moisture were dried in different ways and gave the following percentage of the original yield of tar.

(1)	In steam oven	to 15% moisture	99·2%.
	In air oven	to 15% ,,	98·9%.
	In air oven at 105° C.	to 0% ,,	95·0%.
(2)	After air drying	to 24% ,,	93·5%.
	Steam oven	to 7·5% ,,	93·5%.
	Drying oven	to 15% ,,	92·9%.
	Air oven at 105° C.	to 0% ,,	94·1%.

Retorting was done in a gas-heated iron tube through which carbon dioxide was passed and the amounts of tar calculated as anhydrous material.

Thermal Decomposition of Oil Shales.—R. H. McKee & E. E. Lyder. *J. Ind. Eng. Chem.*, 1921, **13**, 613–17.

Colorado shale was heated for a given time at different temperatures between 370° C. and 430° C. by means of a bath of molten lead and the yields of light oils and semi-solid bitumen, soluble in carbon bisulphide, noted. The primary product of decomposition of the oil-forming

material of the shale appears to be the bitumen, which is formed at 400°–410° C., and from which the light oils are produced by cracking.

PREPARATION OF HYDROCARBON OIL FROM A VEGETABLE OIL.—A. Mailhe. *Comptes rend.*, 1921, **173**, 358–9.

If linseed oil is passed over a mixture of electrolytic copper and magnesia in the presence of hydrogen a mixture of aromatic and cyclic hydrocarbons is obtained, amongst which benzene, toluene, xylene, cyclohenane, and methylcyclohenane were identified. A petrol of sp. gr. 0·7607 at 23° C. and a kerosine of sp. gr. 0·8644 at 41° C. can be obtained by distillation.

DETERMINATION OF WATER IN PETROL.—C. W. Clifford. *J. Ind. Eng. Chem.*, 1921, **13**, 628–31.

Five to 15 l. per hour of dry air is bubbled through the petrol for 1–2 hours, and then through two calcium chloride tubes. In order to displace petrol vapours dry air at the rate of 5 l. per hour is passed for at least 1 hour through the calcium chloride tubes, which are then weighed.

SOLUBILITY OF WATER IN PETROL.—C. W. Clifford. *J. Ind. Eng. Chem.*, 1921, **13**, 631–2.

Petrol, with sp. gr. 0·70 and b.p. 40°–145° C., when saturated with moisture at 25° C. contains 0·0085–0·0110% by weight of water, and at 37·5° C. 0·0121–0·0175%.

DETERMINATION OF THE COMPOSITION OF LUBRICATING GREASES.—J. Marcusson and H. Smelkus. *Petroleum*, 1921, **17**, 818–19.

Water and the fatty portion are removed by extraction with cold acetone, leaving soaps and inorganic material.

In the presence of mineral oils or montan wax calcium chloride is added to the acetone in the flask of a Soxhlet and the last traces of fatty matter removed by a mixture of acetone and benzine (2 : 1). In order to distinguish between montan wax and animal and vegetable fats the fatty acids are separated and examined, those from the former being hard with m.p. 73°–77° C. and a mean molecular weight of 460. Raw montan wax differs from distilled by containing wax-alcohols and ketones, which may be identified by saponifying the acetone-soluble portion and treating the unsaponifiable matter by Holde's method for the estimation of paraffins. The following substances have lately been found in greases: magnesium chloride and hydroxide, calcium chloride and sulphate, sodium chloride and Metanil yellow. One sample was composed of 75% mineral oil and 25% sulphite-cellulose waste lye.

HYDROGENATION OF HYDROCARBONS.—R. Tern. G.P. 336,334.

Petroleum residues, heavy tar oils, or asphalt are subjected to a temperature of 250° C. under 20 atms. pressure for six hours in the presence of hydrogen and a catalyst of metallic iron. When prepared by the electrolysis of iron salt solutions with platinum electrodes the catalyst is more active and resistant to poisons than when iron compounds are reduced.

TREATMENT OF MINERAL OILS FOR USE IN SWITCHES AND TRANSFORMERS.—H. Rebs. G.P. 336,342.

The oils are treated with 20% of naphthlene, methyl alcohol, pyridine, anthracine, creosote, or oil of turpentine in order to dissolve the contained sediment.

FUEL FOR EXPLOSION ENGINES.—Eberhard und Jacob. G.P. 338,201. Addn. to 319,893.

Petroleum or lignite tar distillates boiling up to 300° C. and sp. gr. above 0·75 and 0·8 respectively are mixed with acetic esters.

MANUFACTURE OF LUBRICANTS, ESPECIALLY SUBSTITUTES FOR CYLINDER OILS.—H. W. Klever. G.P. 301,773.

The pitch distillation residues as well as the high boiling fractions of mineral, coal, shale, or resin oils are hydrogenated under pressure at high temperatures in the presence of catalysts, e.g. heavy metals, metals of the alkalis and alkaline earths and their compounds, carbon, graphite, fuller's earth, and the like. Before hydrogenation sulphur and the like must be removed by extraction, distillation under high vacuum, or heating with finely divided metals and hydrogen under pressure. Low-boiling fractions are removed by distillation and the residue used for lubricants.

MANUFACTURE OF STABLE, HIGHLY VISCOUS LUBRICATING OILS.—H. Klever. G.P. 337,157.

The addition of organic substances of high-boiling point to solutions of metal salts of fatty and resin acids in mineral oils renders them stable so that their high viscosity changes very little with rise of temperature or on keeping. 0·5 to 1% of benzyl alcohol, cyclohexanol, hydrogenated crude cresol, terpineol, benzyl acetate, benzyl ethyl ether, acetone oil, cyclohexanones, or the like, may be added to a solution of aluminium oleate in spindle oil.

ARTIFICIAL ASPHALT.—W. Daitz. G.P. 336,603.

The residues obtained in the treatment of crude mineral oils and their distillates are neutralised with burnt magnesia and water, and after separation of the salt solution the resulting pitch is air blown for 20–60 hours at 130°–170° C. It has then lost its stickiness and can be sprayed.

COMPOSITION OF HIGH- AND LOW-TEMPERATURE TARS.—H. Tropsch. *Brennstoff-Chem.*, 1921, **2**, 251–2.

A low-temperature tar from an Upper Silesian coal was examined by the method of Marcusson and Picard (*J.S.C.I.*, 1921, 462A). It was thin, dark brown, had sp. gr. 0·964 at 15° C. and contained 0·5% moisture; 34% was soluble in 5 N caustic soda. Distillation commenced at 72° C., 3% to 100°, 18% to 200°, 53% to 300°, and 70% to 360° C. The fractions to 280° C. (48%) and 280°–360° (22%) contained respectively 30·4% and 32% of alkali soluble components. The whole tar, except 0·6% of a solid brown substance, was soluble in ether.

VISCOUS LUBRICATING OILS FROM COAL TAR.—F. Schreiber. *Z. angew. Chem.*, 1921, **34**, 425–6.

Low viscosity and a tendency to deposit crystals of anthracine, etc.,

are the usual characteristics of lubricants made from crude anthracine oils or mixtures with mineral oils. These drawbacks are overcome by dehydrogenising with sulphur (G.P. 330,970), all of which is eliminated as hydrogen sulphide and the hydrocarbons condense to products of high viscosity with no tendency to crystallise. Sp. gr. 1·14; flash point 170° C.; viscosity at 50° C., 4·5° Engler.; solidif. pt. –15° C.; distillation to 300° C., 0%; to 340°, 40%; to 400°, 80%; to 430°, 95%. It is almost odourless and claimed to be superior to mineral lubricants.

Oil-proofed Container.—C. Ellis. U.S. Pat. 1,385,941.

Concrete tanks are made oil-proof by washing with an acid solution of sulphite cellulose waste liquor, whereby the latter reacts with the alkali of the concrete.

Manufacture of Naphthenes.—C. Weizmann & D. A. Legg. E.P. 165,452.

When n-butyl alcohol is passed through pumice, coated with aluminium oxide, at 250°–320° C. a mixture of Δ_1- and Δ_2-butylene is formed containing 80%, and at 360°–390° C. almost 100% of the former in nearly theoretical yield. The liquified butylene is treated with anhydrous aluminium chloride (56 g. to 1 g.) at –10° C., or in a pressure vessel up to 15° C., and polymerisation is complete in about 2 hours. The yield of naphthenes is practically quantitative.

Lubricating Oils for use in Diesel Engine Air Compressors.—Anon. *Petroleum World*, **18**, 242.

The most successful generally possess the following properties: sp. gr. at 15° C., 0·870–0·915; viscosity (Redwood) 400–1000 secs. at 70° F. and 75–125 secs. at 140° F.; closed flash point not less than 400° F. Straight mineral oils are usually better than compounded oils.

The recovery of Lubricating Oil.—A. J. Wilson. *Petroleum World*, **18**, 29–30.

A résumé of the means most commonly employed for treating oil that has already passed through the engine and become too dirty for further use.

The effect of Crystalline Paraffin Wax on the Viscosity of Lubricating Oil.—E. W. Dean & L. E. Jackson. *U.S. Bureau of Mines, Reports of Investigations*, No. 2249.

Changes up to 9% in the paraffin wax contact of Pennsylvania lubricating oils have a negligible effect on the viscosity through a considerable range of temperature.

Theory of the Origin of Hydrocarbons.—H. L. Fairchild. *Oil and Gas J.*, **19**, No. 51, 70.

Under the new theory of earth origin (planetesi, mal) vast amounts of organic hydrocarbons may have been held in strata now below the observable rocks, and these have been forced up to form reservoirs of volcanic emanations. It is thus not necessary to trace the source of an oil pool to a particular limestone or shale.

GEOLOGY OF THE PERUVIAN OIL FIELDS.—V. F. Marsters. *Oil and Gas J.*, **19**, No. 46, 78–80.

Petroleum from the northern fields contains 15–25% petrol, 24% kerosene, and 35% of lubricants, and has an asphaltic base. From the Pusi area the oil has a paraffin base with little or no petrol and 7–20% kerosene, and very considerable lubricants.

THE TECHNICAL ANALYSIS OF PETROLEUM.—I. Lazennec. *Age de fer*, **37**, 1058–60.

A brief outline of determinations which should be carried out on crude petroleum, benzine, and kerosene.

THE REFINING OF CRUDE PETROLEUM.—A. H. Low. *Colorado School of Mines Quarterly*, **15**, No. 2, 3–10.

A non-technical description of refining practice.

PETROLEUM UNDER THE MICROSCOPE.—J. Scott. *Petroleum World*, **18**, 20–2.

Through insufficient washing during refining sulphonic acids often remain, and may be detected by heating with an equal volume of freshly distilled aniline which combines to form a turbidity. Three micro-photographs of the salts formed are shown.

THE OIL-NITROGEN PROBLEM.—*Ibid.*, 125–6.

Nitrogen is seldom present in petroleum, but natural gas sometimes contains 80%. If petroleum is derived from animal sources bacterial decomposition could liberate ammonia and hence free nitrogen. Sulphate of ammonia is commonly found in oil wells.

Ibid., 160–1. An argument to prove that bacteria have had and still have considerable influence in both crude and refined petroleum.

FORMATION OF PETROLEUM FROM FISH OILS. ORIGIN OF JAPANESE PETROLEUM.—K. Kobayashi. *J. Chem. Ind. Japan*, **24**, 1–26.

Petroleum was prepared from fish oils by dry distillation with acid clay. Reasons prompting the investigation were: (1) Topographical relationship exists between the distribution of Japanese petroleum and acid clay. (2) The petroleum is mostly found mixed with sea water. (3) Acid clay and neutral salts heated together form free acids. (4) Certain fish oils contain hydrocarbons, e.g. squalene. Experimental details are given and figures showing the near relationship of the artificial and natural benzines and kerosines, from which is deduced the theory of marine animal origin of Japanese petroleum.

BURNING PETROLEUM.—E. C. B. Smith. *Petroleum Times*, **5**, 609–10.

A description of fuel oil burners of different types.

PURIFYING OILS.—A. J. Paris. E.P. 161,253.

Petroleum distillates are purified by compressing their vapour or spray with a liquid having no chemical action thereon, e.g. glycerol, turkey-red oil, mineral lubricating oil, etc., in the presence of an oxygen free gas.

STATISTICAL REVIEW OF THE MID-CONTINENT FIELD, 1912–20.—M. Bates & B. H. Lasky. *Nat. Petroleum News*, **13**, No. 13, 67–79.

A statistical report on production, consumption, drilling, costs, etc.

ORIGIN OF OIL.—H. W. Hixon. *Oil and Gas J.*, **20**, No. 3, 76.

Polemic with Fairchild (*Oil and Gas J.*, **19**, No. 51, 70). Claims that diffusion in a gaseous planet accounts for hydrocarbon gases in interior of earth and that salt domes may result from sublimation from gaseous interior. Dry holes and productive oil-fields should not be close together if organic theory of petroleum formation is true.

PRELIMINARY REPORT ON PETROLEUM IN ALASKA.—G. C. Martin. *U.S. Geol. Survey Bull.*, 719.

Two hundred and seventy-five million gallons of petroleum were exported from 1905–19, but geological data from the wells drilled do not indicate great deposits. The Katalla, Yakataga, Cook Inlet, and Arctic Peninsula fields are described.

THE WELL AT CALDONES, ASTURIAS.—M. Ruys-Falco. *Bol. Inst. Geol. Espana*, **37**, 3–26.

At 560 m. gas was struck, with composition H, 0·46%, CH_4, 95·51%, C_2H_6, 2·14%. N, 1·89% and calorific value 8590–9553 calories.

FLASH-POINT APPARATUS.—F. W. Shulenberger. *Paint, Oil, and Chem. Rev.*, **71**, No. 24, **9**, 18–20.

Descriptions of standard flash point apparatus with discussion of their merits.

DISTILLING TAR OILS, MINERAL OILS, ETC.—*Chemische Fabriken Worms Akt.-Ges.* E.P. 156,255.

The yield of low-boiling distillates is increased and the formation of coke diminished by adding a catalyst, such as an acid, salt, metal, metal compound, or a base. Before distillation the materials may be heated under a reflux apparatus or under pressure. During distillation inert gases may be passed through the still and the distillation may be repeated to further lower the boiling-point.

LOSSES IN THE DEHYDRATION OF OIL.—J. H. Wiggins. *Nat. Petroleum News*, **13**, No. 26, 59–65.

The plant comprised two dehydrators and three stock tanks, the emulsified oil being passed through hot water in such a way that it remained two, six, and twelve hours in the three tanks respectively. At 84° and 105° F. the loss is greatest in the third stage, at 125° F. it has decreased, and at 150° F. it is less than in the second stage. At 200° F., the usual temperature for dehydrators, the loss is 8·5%.

REDUCING LOSSES BY EVAPORATION.—C. P. Buck. *Oil and Gas J.*, **20**, No. 5, 80–1.

The capilliary adhesion of oil to fibrous material overcomes the tension of oil films surrounding water bubbles, thereby breaking emulsions and enabling a dehydration filter to work at lower temperatures, with consequent reduction of losses. By thus operating at 84° F. a saving of 4% of oil is effected over the usual type of dehydrating plant working at 150° F.

BLENDED GASOLINE CONTAINING CASING-HEAD GASOLINE.—F. Bordas. *Ann. fals.*, **13**, 539–43.

Owing to the increased fire risks and marked heavy residue the French

Ministry of Finance have instituted investigations to differentiate between blended and straight run gasoline. Modifications of the current tests are described.

PROPOSED DISTILLATION TEST FOR GASOLINE.—Anon., *Nat. Petroleum News*, **13**, No. 24, 33–4.

A tentative method of distillation test for gasoline, naphtha, kerosene, and similar petroleum products.

ACTION OF OXIDISING AGENTS ON VASELINE AND PARAFFIN.—A. Langer. *Chem. Ztg.*, **45**, 466.

The oxidising effect of $KMnO_4$, NaO Cl, $K_2Cr_2O_7$, and HNO_3 on yellow vaseline oil and liquid paraffin and paraffin wax are described. Indefinite resinous products are mostly obtained, though paraffin wax gives a lead salt indicating acids of the oleic series.

CRACKING HYDROCARBON OILS.—W. M. McComb. U.S. Pat. 1,374,858.

A mixture of oil and steam is passed through a tube heated in such a manner that the temperature at the oil inlet is equal to the initial, and at the outlet to the final boiling-point of the oil. The increase in temperature from one end to the other of the tube corresponds with a fractional distillation of the oil. This treatment is stated to produce very little fixed gas and carbon.

MOTOR FUEL FROM HYDROCARBON OILS.—J. R. McCabe. U.S. Pat. 1,376,713.

Vapours produced by heating hydrocarbon oils are mixed with hydrogen and passed through metal tubes, across which pass high-frequency electric discharges.

BLENDED FUEL FROM NATURAL GAS AND LIQUID HYDROCARBONS.—E. C. D'Yarmett. U.S. Pat. 1,376,925.

Crude petroleum or the like is heated in a closed vessel and natural gas forced into the liquid, so that the gas and oil vapours mingle under pressure, and are then drawn off and condensed.

PETROLEUM STILL.—A. D. Smith. U.S. Pat. 1,374,402.

The oil circulates through a series of tubes forming the lower part of the still and an upper part consisting of a horizontal drum with sloping bottom, which promotes flow of the oil and lessens deposition of carbon.

APPARATUS FOR DISTILLING HYDROCARBON OILS.—S. F. Stephens. U.S. Pat. 1,375,427.

The oil is fed on to a rotating plate inside the still, and is thus flung in a spray against the walls of the still.

DISTILLING HYDROCARBON OILS.—W. C. Averill. U.S. Pat. 1,375,245.

Pale lubricating oil and distillates containing petrol can be produced from asphaltic petroleum of high sulphur content by distillation wherein a portion of the still furnace flue gases are cooled and passed through the oil.

ELECTRIC TREATMENT OF LIQUID FUEL.—E. E. Wickerskam. U.S. Pat. 1,376,180.

The final boiling-point of liquid fuels, such as crude oil, kerosene, or

petrol, is lowered by passing through it electric sparks as it flows from the tank to the carburettor.

PARAFFIN WAX AND LUBRICATING OILS.—E. Erdmann. E.P. 156,694.

After removal of volatile fractions from shale, coal, or lignite tars, acetone or a homologue or ethylacetate is added to precipitate paraffin wax, and the solvent removed from the lubricating oil by superheated steam.

OXIDATION OF PARAFFIN WAX.—F. Fischer & W. Schneider. *Ges. Abhandl. Kennt. Kohle*, **4**, 35–142.

Six publications on the oxidation of paraffin wax and the treatment of the products obtained. Oxidation was done both under pressure and in the open by air blowing the heated wax in the presence of catalysts. Fatty acids were the principal products of oxidation, the yield rising to 74% of the paraffin consumed. They are suitable for soap making.

MONOGRAPHS ON MINERAL RESOURCES OF THE BRITISH EMPIRE—PETROLEUM.—By H.M. Petroleum Dept. & H. B. Cronshaw.

ACTIVATED CARBON.—E. C. Ardagh. *J. Soc. Chem. Ind.*, 1921, 230–3T.

A comprehensive review of the subject and methods of manufacture.

APPARATUS FOR DISTILLING UNDER PRESSURE.—V. L. Emerson. E.P. 143,217.

A fire-heated still somewhat in the form of a Babcock and Wilcox water-tube boiler with two side drums connecting the lower with the upper cross drum. A propeller is provided to increase the circulation.

FRACTIONAL-DISTILLATION PROCESS AND APPARATUS.—V. T. Gilchrist. U.S. Pat. 1,386,467.

A method whereby vapours are condensed in fractions and each fraction redistilled by the heat of the succeeding vapour fraction.

TRANSFORMATION OF COAL INTO OILS BY HYDROGENATION.—F. Fischer & H. Schrader. *Brennstoff-Chem.*, 1921, **2**, 257–61.

A mixture of carbon-monoxide and steam was tried instead of sodium formate. At 400° C. under ordinary pressure hardly any action occurred, but the yield of oil increased with rise of temperature and pressure. 500° C. was the highest employed, at which the yield of oil was much greater than when heating coal with hydrogen under pressure, but rather less than with sodium formate.

DISTILLATION OF MINERAL OIL.—E. A. Rudigier. U.S. Pat. 1,386,077.

A method of dehydrating oil whereby it is made to flow on to a table suspended in the vapour space of a still in operation. The heat of the vapours evaporates the water and the dehydrated oil flows into the oil being distilled.

OIL-CRACKING PROCESS AND APPARATUS THEREFOR.—D. E. Day. U.S. Pat. 1,386,768.

High-boiling hydrocarbons are passed through a cracking zone and

the resulting low-boiling vapours condensed. The supply of high-boiling oil is then stopped and the carbon deposited in the cracking zone is burnt, the heat generated being used for heating a second cracking zone.

MANUFACTURE OF LUBRICATING OILS.—J. Harger. E.P. 167,789.

Hydrocarbon oils, heated to 50°–300° C. are treated with air or oxygen in the presence of a catalyst, composed of compounds of manganese, lead, or mercury, until the product contains 0·2–1·0% of fatty acid.

DEHYDRATION OF MINERAL OILS.—E. Theobald. G.P. 338,818.

By agitating the hot oil with a finely divided material, preferably having an alkaline reaction, which is insoluble in water, such as kieselguhr or coal ash.

OIL-RESISTING PAINT.—C. H. Ivinson & G. S. Roberts. E.P. 169,258.

A mixture which resists the action of oils, fats, and spirits is made from casein, lime, or other alkali-sodium fluoride, ferric oxide—or other oxide not affected by lime—and water.

MANUFACTURE OF ASPHALT.—H. R. Wardell. U.S. Pat. 1,385,511.

Mixed base petroleum residue and asphaltic base residue are mixed and heated to a temperature sufficient to drive off water, but not high enough for destructive distillation, whilst air is blown through until an asphalt, solid at ordinary temperatures, is obtained.

PRODUCTION OF ALCOHOL FROM GAS CONTAINING ETHYLENE.—C. A. Basore. U.S. Pat. 1,385,515.

50% to 70% of water is added to a mixture of sulphuric acid and ethyl hydrogen sulphate, the whole heated in a closed vessel and alcohol and water distilled off.

RECLAIMING SLUDGE ACID IN PETROLEUM REFINING.—W. H. Simonson. U.S. Pat. 1,384,978.

The weak acid is concentrated by heating at a temperature sufficient to drive off water, but not to char organic matter, which is achieved by the use of a partial vacuum.

COMPOSITE MOTOR FUEL.—J. P. Foster. U.S. Pat. 1,384,946.

A mixture consisting of alcohol 63%, ether 34%, kerosene 2%, and anilin 1%.

CRACKING HYDROCARBON OILS.—E. F. Engelske. E.P. 166,989.

Heavy oil and hydrogen gas are heated and passed under high pressure into opposite ends of a cracking chamber, filled with a catalyst, such as charcoal, coke, nickel, copper, or iron, and heated to the same temperature as the oil. Unconverted oil is reintroduced into the system.

DISTILLATION OR CRACKING OF HYDROCARBON OILS.—T. J. Greenway & C. Dally. E.P. 168,335.

A vertical retort is filled with porous incombustible material, through which hydrocarbon oils are allowed to trickle, and is heated by the combustion of a portion of the oil at the lower surface of the incombustible packing. Distillation and cracking of the descending oil is

brought about by the ascending hot combustion gases. The retort can also be heated externally and internally by auxiliary combustion gases.

CRACKING AND DISTILLING HYDROCARBON OILS.—R. H. Brownlee. E.P. 146,251.

The apparatus consists of a furnace, on the opposite outside walls of which are two vertically arranged series of horizontal drums connected by sloping tubes through the furnace. Oil overflowing from a lower drum through the sloping tubes meets a counter current of steam, and is carried upwards through succeeding tubes and drums. Cracked light vapours escape to a condenser, whilst heavy oils condense in the drums and re-enter the cracking system.

CONVERSION OF ALIPHATIC HYDROCARBONS INTO FATTY ACIDS.—*Deutsche Erdöl Akt.* E.P. 148,892.

By spraying hydrocarbon oils, such as petroleum, in a liquid atomised condition into a chamber containing oxygen heated to about 80° C. A catalyst such as nickel oxide may be employed.

CONVERSION OF HEAVY HYDROCARBONS INTO LOWER BOILING PRODUCTS.—C. Cordes. E.P. 147,648.

Heavy oils are distilled, with the aid of steam, in the presence of a large volume of a hydro-silicate such as that found in Florida. By this means a water-white distillate, containing a larger proportion of low-boiling components than could be obtained by ordinary distillation, is produced without the use of sulphuric acid. Sulphur compounds are also largely eliminated.

IMPROVEMENTS IN HYDRAULIC OIL STORAGE.—F. G. Farr. E.P. 157,739.

A device for preventing oil being discharged into the water drain when filling an hydraulic oil storage tank.

DISTILLATION OF HYDROCARBON OILS UNDER PRESSURE.—Standard Oil Co. E.P. 147,715.

When distilling heavy oils under pressure a certain amount of high-boiling constituents is carried over with the light vapours into the condenser. By interposing a length of vertically inclined pipe between the still and the condenser proper the heavier portions of the distillate are condensed and run back to the still.

APPARATUS FOR FRACTIONAL DISTILLATION.—A. McD. Duckham. E.P. 170,324.

The fractionating column is divided into sections which are cooled by the liquid about to be distilled, any vapours formed passing with the liquid into the still. The column thus acts as a preheater and condenser.

DISTILLATION OF HYDROCARBON OILS, ASPHALTS, ETC.—E. F. Engelke. E.P. 170,140.

Continuous distillation is performed in the usual way, with the substitution of permanent gases rich in hydrogen for steam. Improved speed and products of distillation are claimed.

COLOURING PETROL AND OTHER LIQUID FUELS.—L. Knight. E.P. 170,075.

Petrol is coloured by means of a dye which is soluble in petrol, but insoluble in water, by which means different grades of petrol are distinguishable and the presence of water can be immediately detected.

STORAGE AND DRAWING OFF HIGHLY INFLAMMABLE LIQUIDS.—J. Muchka. E.P. 153,912.

Inflammable liquids are stored in a tank wherein the vapour space above the liquid is filled with a non-inflammable gas at atmospheric pressure. By means of an artificial leak in the suction pump liquid cannot be withdrawn unless gas enters and seals this leak by means of an injector device. The device does away with all mechanical valves.

OBTAINING LIGHTER PRODUCTS FROM PETROLEUM.—H. P. Chamberlain. E.P. 146,472.

Hydrocarbons having a viscosity between 70 and 170 seconds (Engler) at 100° F. are decomposed by distillation under a pressure of about 30 to 75 lb. per sq. in.

CRACKING OILS.—J. H. Adams. E.P. 141,689.

Oil is cracked in the liquid phase under pressure by passing through a heated tube in which rotates a solid cylinder of almost equal diameter carrying a helical scraper for the removal of carbon.

STILL.—A. J. Trinyi. E.P. 144,294.

A still containing radiating fins on the interior walls. These conduct heat to the liquid through the film of vapour adhering to the walls of the still.

VISCOSITY TEMPERATURE CURVES OF AMERICAN CRUDE OILS.—E. W. Dean & F. W. Lane. *J. Ind. Eng. Chem.* **13**, 779–86.

300 c.c. each of Pennsylvania, California, and Wyoming crude oils were distilled through a Hempel column until a vapour temperature of 275° C. was obtained. A spray catcher containing three gauze cones was then substituted for the Hempel column, and distillation continued under a pressure of 40 mm. up to a vapour temperature of 300° C. Fractions were then taken every 25° C. and the viscosities observed at different temperatures in a special Ostwald viscometer. Viscosity-temperature curves show changes increasing in the order: Pennsylvania, Wyoming, California. With Pennsylvania oil the undistilled residue, distillates, and a mixture of both show the same characteristics. A mixture of Pennsylvania residue and California distillate has characteristics which are an average of the two.

In each oil the kerosene fractions give curves similar to the lubricating oils. The viscosity-temperature curves follow the equation, $Vk = 1/(k + At + Bt^2)$, where Vk is the kinematic viscosity, t the temperature, and K, A, and B are constants characteristic of each fraction of each oil. Three experimentally determined points must be known in order to calculate a viscosity-temperature curve.

ASPHALT IN THE TAR SANDS OF NORTHERN ALBERTA.—V. K. Krieble & W. F. Seyer. *J. Amer. Chem. Soc.*, **43**, 1337–49.

Analysed by Marcusson's method (*J.S.C.I.*, 1916, 1099) the asphalt

gave 2·0% saponifiable matter (including free acids), 22·5% asphaltenes, 24% resins, and 51·5% of oily constituents. Ultimate analysis of the asphalt gave S, 2·73%; C, 84·49%; H, 11·23%; N, 0·04%. Hydrocarbon oil was extracted by light petroleum from the sands and filtered through fuller's earth to remove resin. By distilling under 0·4 mm. pressure thirteen apparently pure hydrocarbons were isolated belonging to the series C_nH_{2n}, C_nH_{2n-2}, and C_nH_{2n-4}.

TRANSFORMER OIL SLUDGE.—C. J. Rodman. *Trans. Amer. Electrochem. Soc.*, 1921, 105–12.

Asphaltic, soap, and carbon sludge are described, the first two being caused by insufficient refining of oil containing unsaturated hydrocarbons, water, resins, etc., and the last by electrical breakdowns. Asphaltic sludge possesses good electrical properties, but is liable to cause local overheating and consequent breakdown. Soap sludge forms slowly, and being partially soluble in the oil is difficult to remove. It has low insulating power. Highly refined oil of the saturated paraffin series can be used for years if filtered when the dielectric strength begins to diminish.

MOTOR FUEL.—E. W. Stevens. U.S. Pat. 1,388,531.

A substitute for petrol composed of petroleum oil, ethyl alcohol, methyl ethyl ether, and an oily material for blending the alcohol and oil and retaining the ether.

DILUENT FOR LIQUID FUELS.—A. Wipfler. G.P. 339,139.

Sulphite-cellulose waste liquor is added to oil for spraying into combustion chambers.

LUBRICATING OIL.—H. M. Wells & J. E. Southcombe. E.P. 168,076.

Oil soluble organic bases or amino-acids and their salts, such as *p*-toluidine and glycocholic acid, are added to lubricating oils.

PURIFYING HYDROCARBON OILS.—E. B. Cobb & C. I. Robinson. U.S. Pats. 1,387,835 and 1,387,868.

Oil is treated with strong sulphuric acid, and oil soluble sulphonates removed by washing with isopropyl alcohol.

LOWERING THE BOILING- AND FLASHING-POINTS OF KEROSENE.—W. M. Wheeler. U.S. Pat. 1,387,876.

Kerosene vapour and steam are gradually heated higher under slight pressure. The pressure is then released and the temperature increased, the vapour being subsequently condensed.

DISTILLATION AND CRACKING OF PETROLEUM.—E. M. Clark. U.S. Pat. 1,388,514.

High-boiling oils are distilled under pressure, fresh oil being introduced into the still through the same pipe that connects the still to the condenser. Heavy vapours are thus condensed and returned to the still and light portions distilled from the fresh oil.

CRACKING HYDROCARBONS.—J. W. Coast. U.S. Pat. 1,388,629.

Low-boiling oils are cracked at a high temperature and pressure, and without cooling the vapours are forced into a high-boiling oil being distilled at a lower temperature and pressure.

MANUFACTURE OF WATER-WHITE MEDICINAL OILS.—E. B. Cobb. U.S. Pats. 1,388,517 and 1,388,832.

Oil of viscosity about 40 secs. (Engler) at 100° F. is treated with sulphuric acid, distilled with a special agent for preventing decomposition, retreated with sulphuric acid and filtered through solid decolorising material. Stock of viscosity, 80 secs. at 100° F., is compounded of distillates of various viscosities and sp. gr. in such a way that 50–95% of the component parts are heavier and more viscous than the whole.

OXIDATION OF LIQUID HYDROCARBONS.—G. Teichner. E.P. 148,358.

Heavy hydrocarbon oils are treated with half their weight of 20% oleum at 60–80° C. for removal of all hydrocarbons except those of the methane series, the residual oil being readily oxdisable by air or oxygen in the presence of a catalyst such as zinc stearate at 110° C. The oxidation product has a saponification value of 150–360.

RATE OF SOLIDIFICATION OF PARAFFINS.—K. Fricke. *Chem. Zeit.*, 1921, **45**, 891–2.

A hundred gms. of wax are melted at 65° C. and poured into a metal dish, 11 × 6 × 3·5 cm. deep, and fifty minutes after the first signs of solidification are noticed a weight of 2205 gms. is placed on the surface of the wax at a point 2·5 cm. from the side of the dish. The weight is in the form of a square rod of 19 sq. cm. cross section attached to the rest of the weight. Tests are made every five minutes until the rod makes no appreciable impression, the time required being termed the solidifying period. Paraffin wax for candle making should solidify within 65 minutes when the air temperature is at 17°–20° C.

AIR-BUBBLE VISCOMETER.—V. R. Abrams, J. T. Kavanagh, & C. H. Osmond. *Chem. and Met. Eng.*, 1921, **25**, 665–6.

The viscometer consists of a glass tube 21 cm. long and 5·2 mm. internal diameter, with a bulb at one end and at the other a ground-on cap, in which is a hole capable of coinciding with a groove in the tube. A length of about 10 cm. is marked off on the tube. The tube is filled with oil (4 c.c.), the cap turned until the hole and groove register and the apparatus immersed in water at the desired temperature until expansion of oil ceases. The tube is then sealed by turning the cap, inverted, and the time taken by the bubble to travel between the marks on the tube is noted. The tubes are calibrated against Saybolt viscometers, and are accurate to 1% with oils of less than 80 seconds Saybolt.

INCREASING THE SPECIFIC GRAVITY AND FLASH-POINT OF LIQUID FUELS.—L. W. Bates. U.S. Pat. 1,390,229 and 1,390,233.

Sufficient solid carbonaceous particles are added to liquid fuels to produce a free-flowing mixture heavier than water and having a flash-point above the temperature of preheat necessary for proper atomisation. Peptising coal tar fractions are added to stabilise the mixture.

MANUFACTURE OF LIQUID FUEL.—L. W. Bates. U.S. Pat. 1,390,232.

Solid fuel is pulverised in oil of low viscosity and oil of high viscosity

then mixed in, the proportions of ingredients being such that the mixture is heavier than water.

SEPARATING USEFUL PRODUCTS FROM THE EXHAUST OF INTERNAL COMBUSTION ENGINES.—A. J. Paris. U.S. Pat. 1,388,480.

A heat-absorbing agent other than water is fed into the exhaust pipe and liquifiable products subsequently condensed.

REFINING HYDROCARBONS.—C. R. Burke. U.S. Pat. 1,389,934.

An ordinary still is furnished above with a holder capable of containing nearly the whole still charge. A portion of the oil vapours passing into the holder are condensed, and on returning to the still act as a scrubber of the ascending vapours. Uncondensed vapours are led to a condenser.

REFINING AND CRACKING LIQUID HYDROCARBONS.—F. E. Wellman. U.S. Pat. 1,390,002.

Oil is distilled under low or atmospheric pressure, and the total distillate cracked at high temperature and pressure and the heavier portions of the resulting product again distilled and cracked.

MOTOR FUEL.—*Chem. Fabr. Worms.* G.P. 339,989.

A mixture of acetaldehyde with one or more hydrocarbons of the benzene series.

VISCOMETER.—A. E. Bawtree. E.P. 169,204.

The measuring chamber of a Redwood type viscometer is partially contained in a glass cylinder provided with a tightly fitting cover, having a three-way cock through which air may be forced under pressure. The efflux orifice of the measuring chamber is immersed in the oil to be tested and the time required for the oil to rise under pressure to the index mark near the top of the chamber is noted.

CATALYTIC OXIDATION OF PETROLEUM OILS.—C. E. Waters. *J. Ind. Eng. Chem.*, 1921, **13**, 901–03.

An investigation into the effect of metals employed in the manufacture of transformers and bearings on heavy petroleum oils. A paraffin base oil and naphthalene base oil were examined. The oil was heated to 250° C. for two hours and strips of the metal suspended so that they were surrounded by a mixture of oil vapours and air. The weight of the precipitates of oxidised oil was taken as the measure of activity as an oxygen carrier exerted by the metal. Zinc and aluminium did not act as oxygen carriers; cold-rolled steel, cast iron, nickel, and cobalt increased the asphalt content slightly. Ferric oxide had a greater effect. Nickel and cobalt oxides caused a small increase in the rate of oxidation, the former being the more active. Copper proved the most active metal, but was exceeded by its oxide. The varnish formed on brass acted as a protection to the metal, but by itself proved to be a catalyst. From these results it appears that transformers should be constructed of zinc or aluminium, and bearings should not contain copper.

ACTION OF ANHYDROUS STANNIC CHLORIDE ON PETROLEUM.—G. Torossian. *J. Ind. Eng. Chem.*, 1921, **13**, 903–04.

Tarry, resinous, and oxygenated bituminous substances, as well as

sulphur compounds contained in crude oil or its unrefined distillates, react with anhydrous stannic chloride to form bulky precipitates by polymerisation of the impurities. The reaction is regarded as physical as well as chemical. The reagent can be regenerated by strong sulphuric acid. It has no action on saturated hydrocarbons. The precipitates with different oils and fractions are so distinctive that the reaction may be used for quantitative and qualitative tests.

Action of Selenium on high-boiling Mineral Oils.—K. Graefi. *Z. angew. Chem.*, 1921, **34**, 509.

When heated with high-boiling mineral oils the action of selenium is analogous to that of sulphur and oxygen, hydrogen selenide being liberated, accompanied by formation of black asphaltic substances and an increase of the mean molecular weight. Evolution of gas commences at 160° C. and increases with rise in temperature. It consists of 70–80% of hydrogen selenide, 2–4% of heavy hydrocarbons, and no free hydrogen. The asphaltic residue contains 1·3% of combined selenium, melts at 35·9° C., has a mean molecular weight of 450 compared with 368 of the original oil, and gives 33·7% of asphaltic compounds insoluble in ether-alcohol mixture.

Process of Distilling Hydrocarbon Oils.—M. Benson. E.P. 169,763.

One part by weight of heavy crude oil and three parts of steam at about 540° C. are forced separately into a mixing chamber in which a pressure of about 100 lb. per sq. in. is maintained by a regulating valve, through which the vapours pass to a condenser. By this means decomposition is claimed to be avoided.

Method of making Motor Fuel.—A. A. Backhaus. U.S. Pat. 1,378,858.

Three parts of ether are mixed with fifty parts of gasoline. Twenty parts of benzol are then added, and finally twenty-seven parts of alcohol.

Manufacture of Gasoline.—G. H. Taber. U.S. Pat. 1,390,472.

Vapours of mixed heavy and light gasoline are obtained from casing-head gasoline by "weathering," and the heavy constituents separated by dissolving in heavier mineral oil, from which they are distilled off and blended with another mineral oil.

Purification of non-liquid Hydrocarbons.—J. M. Treucer & C. S. Benjamin. U.S. Pat. 1,392,370.

Sulphur dioxide is dissolved in benzol and the mixture employed as a solvent for impurities contained in the non-liquid hydrocarbon.

Cracking and Distilling Petroleum Oils.—F. B. Lewis & T. S. Cooke. U.S. Pat. 1,392,384.

Petroleum oils are partially cracked by distilling under pressure, and the vapours scrubbed through petroleum oil maintained at a temperature that will condense the insufficiently cracked portions, but not those sufficiently cracked.

Conversion of heavy into lighter Hydrocarbons.—C. P. Dubbs. U.S. Pat. 1,392,629.

Oil under pressure is passed through a cracking zone in the liquid

phase and then through a zone where partial vaporisation takes place. The unvaporised portion is removed, whilst the vapours are subjected to partial reflux condensation, the condensed portion being returned for further cracking.

FILTRATION OF PARAFFIN WAX.—H. F. Glair. U.S. Pat. 1,392,758.

The process depends on the application of a uniform pressure of oil over the whole surface of the filter. The wax is subsequently melted and removed through the filter.

CRACKING AND DISTILLING PETROLEUM OILS.—A. J. Paris. U.S. Pat. 1,392,788.

The oil is passed through molten metal and the products compressed and condensed.

RECLAIMING USED LUBRICATING OILS.—W. L. Jordan. U.S. Pat. 1,393,223.

The oil is agitated with finely divided kieselguhr and filtered under pressure.

LUBRICATING OIL AND VASELINE FROM PRODUCER-GAS TAR.—L. Landsberg. G.P. 340,074 and 339,988.

The tar is treated at 20°–50° C. with petroleum ether, petroleum or gas oil, undissolved asphalt separated and creosote removed by washing with sodium hydroxide. After removal of the solvent a mixture of paraffin wax and oil remains which is converted into a substitute for vaseline by treatment with concentrated sulphuric acid or oleum and an alkali.

PROCESS FOR BREAKING OILY EMULSIONS.—S. F. Alden & H. C. Eddy. U.S. Pat. 1,394,462.

The emulsion is made to pass between electrodes, between which a current is made to pass intermittently by means of increasing and decreasing its intensity. The particles are thus separated into distinct liquids.

HYDROGENATION OF ACETYLENE TO FUEL OILS.—K. Oda. *J. Chem. Ind. Japan*, 1921, **24**, 1161–6.

By passing a mixture of equal volumes of acetylene and hydrogen over a nickel-mercury catalyst at 25°–35° C. at 3–4 litres per hour a light oil, composed of olifines, and a heavy oil, boiling at 200°–300° C., were obtained. The total yield was 51·7%. The catalyst was made by converting a mixture of nickel nitrate (20 gms.) and mercuric nitrate (2 gms.) into oxide by heating at 250°–300° C., and reducing to the metals by heating to 300° C. with hydrogen.

This mixture is active at a lower temperature than nickel alone.

TREATING MINERAL OILS WITH ALKALINE LIQUORS.—H. Burstin. *Petroleum*, 1921, **17**, 1169–71.

In treating mineral oils with acid and alkali a large excess above that required is generally used. Moreover, the naphthenic acids, obtained by neutralising the alkaline extract, are thus rendered highly impure. Experiments made on a purified oil, to which a known weight of naphthenic acid had been added, proved that complete extraction could be

effected by the use of less than twice the theoretical amount of $\frac{N}{10}$ sodium-hydroxide solution. In large scale practice twelve times the requisite quantity of caustic soda of sp. gr. 1·116 would be used.

Gas oil, extracted with sodium hydroxide solutions of 1·007, 1·037, and 1·075 sp. gr., gave crude naphthenic acids with acid values 106, 121, and 41, and saponification values 115, 135, and 44. On the large scale with sodium hydroxide of sp. gr. 1·022–1·037 naphthenic acids of high quality were obtained, whilst further extraction yielded mainly resins, phenols, and creosote with mere traces of naphthenic acids.

Effect of high Temperatures on Lubricating Oils for Cylinders.—W. Ernst. *Petroleum*, 1921, **17**, 1180–7.

When using condensed water from steam engines as feed water for boilers a certain amount of lubricating oil escapes separation and is carried into the boilers. An apparatus was devised for testing the effect of temperature and pressure on the oils in order to ascertain the resulting action on the boiler plates and their efficacy as lubricants.

The apparatus consisted of an insulated iron cylinder of 1-litre capacity provided with inlet and outlet tubes, thermometer tube, pressure gauge, and an internal electric heating coil. The cylinder was filled with oil of known boiling- and flash-point, which was heated until vapour began to escape from the outlet pipe. This was then closed and nitrogen forced into the cylinder until a pressure of 1 atm. was reached. The temperature was then raised until vapour was again evolved. This was repeated up to a pressure of 15 atms., the temperature being noted at each evolution of gas. A number of oils were thus tested, and in most cases showed a steady rise of vapour pressure with temperature, though with some a rapid rise of pressure at certain constant temperatures indicated decomposition at this point. It was found that inflammable gas was evolved at and above the normal flash-point even when the oil was under pressure, and that decomposition at high temperature both thickens the oil and reduces its viscosity.

The investigation thus proves that the efficiency of a lubricating oil in cylinders progressively decreases; tarry constituents, if present, tend to separate and cause friction, and the oil entering the boilers with the feed water gradually decomposes to a pitch, which reduces conductivity and may cause local overheating.

Manufacture of Liquid Organic Compounds from Coal.—F. Bergius. E.P. 148,436.

Powdered coal is agitated for 6 hours at 400° C., with tar oil or petroleum in the presence of hydrogen under about 100 atmospheres pressure. 87% of the coal is converted to liquid or semi-liquid products if the initial amount of tar-oil or petroleum is twice that of the coal.

Motor Spirit.—C. G. Sesti. E.P. 147,803.

Carbon bisulphide is given a preliminary treatment with quicklime and then mixed with alcohol.

Process for decomposing Coal, Hydrocarbons, and the like.—S. Löffler. G.P. 301,683.

In order to conserve heat and minimise danger when decomposing

coal, hydrocarbons, etc., by heating at high temperatures and pressures, a closed combustion chamber is provided within the reaction chamber. Means are provided for supplying fuel and air to the combustion chamber and controlling it from outside the reaction chamber. The products of combustion either heat the reaction chamber directly or through a liquid medium.

PURIFICATION OF OILS AND OTHER HYDROCARBONS.—M. Benson. E.P. 170,093.

Purification of hydrocarbons is effected by rendering the impurities non-volatile by means of a suitable reagent and distilling off the required fraction by the action of direct steam at the necessary temperature and pressure. For example, in order to desulphurise crude oil the latter is agitated with lime and sufficient superheated steam to raise the temperature to 120° C. under 100 lb. pressure. Enough steam is then added to volatilise the whole or required fraction when the oil is expanded into a chamber containing lime.

MANUFACTURE OF HYDROCARBON OILS.—K. Kobayashi. E.P. 170,264.

If fatty oils and Japanese acid clay are mixed and heated above 500° C. a mixture of hydrocarbon oils resembling petroleum distils off, which may be fractionated and refined in the usual way by acid and alkali treatment. Herring, shark, salmon, and sardine oils are said to be suitable.

DISTILLATION OF HYDROCARBON OILS, TARS, AND ASPHALTS.—E. F. Engleke. E.P. 165,230.

The apparatus consists of a stairway of trays, down which flows a continuous stream of oil to the bottom of the still. Hydrogen, or a gas containing hydrogen such as oil gas or natural gas, is led into each compartment, and after passing through condensers is returned to the still. Steam may be introduced into the bottom of the still.

APPARATUS FOR DISTILLING LIQUID HYDROCARBONS.—A. J. von Groeling. U.S. Pat. 1,378,066.

The still is heated electrically by means of an electric resistance and is also provided with an automatic temperature control.

APPARATUS FOR CRACKING AND REFINING PETROLEUM PRODUCTS.—W. H. Young. U.S. Pat. 1,378,307.

Two coils, placed end to end over a single source of heat, are connected together by a pipe joining the lowest coil of each system.

Thus, oil and steam fed into the top of the upper and cooler coil, flow downwards and returns upwards through the lower and more intensely heated lower coil.

OIL-CRACKING PROCESS.—A. Rogers. U.S. Pat. 1,378,424.

Oil is heated to 315° C. and mixed with enough steam to vaporise the whole. The mixture is then passed through a thin annular space heated to about 430° C.

RETORT FOR EXTRACTING OIL.—A. V. Young. U.S. Pat. 1,378,643.

An inclined retort, with inverted U-shaped section, is provided with

a chain conveyor operating along the bottom. Oil-bearing material is fed in at the upper end.

PROCESS FOR TREATING MINERAL OILS.—A. B. Foster, U.S. Pat. 1,394,486.

A mineral oil and the reagent with which it is to be treated are forced through separate nozzles with sufficient velocity to ensure that the jets of liquid shall disintegrate each other on meeting.

PROCESS OF CRACKING OIL AND APPARATUS THEREFOR.—C. M. Alexander & G. H. Taber. U.S. Pat. 1,381,098.

Oil is cracked by heating in the vapour state with the vapour of a reactive metallic halide.

FRACTIONAL DISTILLATION OF MIXTURES OF HYDROCARBONS.—E. H. French. U.S. Pat. 1,394,488.

The mixture of hydrocarbons is heated to a temperature below that of the mean boiling-point of the desired fraction, but sufficiently high to vaporise the whole fraction when the oil is atomised by an inert gas. For this purpose the oil is led from a reservoir through heating tubes to a separating chamber, where atomisation takes place.

APPARATUS FOR CRACKING HYDROCARBONS.—R. Seeger. U.S. Pat. 1,394,688.

The cracking tubes are surrounded by tubes of larger diameter with which they are not in communication. The space between the tubes is filled with gas or liquid under approximately the same pressure as that in the cracking tubes.

CONDENSING AND TREATING CRACKED OIL DISTILLATES.—R. Fleming. U.S. Pat. 1,394,987.

Oil is distilled under pressure in a cracking still, and the vapours, discharged at high velocity, are led into sufficient cold liquid to condense them.

PRODUCTION OF GASOLINE FROM PETROLEUM OILS.—R. Yates. U.S. Pat. 1,395,075.

High-boiling oils are passed through vertical cylinders containing rotating drums heated externally to 340°–450° C. The pressure of the vapour forces the oil through an opening in the bottom of the drum into the annular space between the cylinder walls and the drum, and thus protects the vapours from local overheating.

PRODUCTION OF VISCOUS LUBRICANTS FROM HYDROCARBONS OCCURRING IN TAR OILS.—L. Lilienfeld. E.P. 149,317.

Fractions of tar oils boiling above 140° C. are treated with acetylene in the presence of 0·5–10% of aluminium-chloride until absorption is complete.

ATMOSPHERIC CORRECTIONS FOR THE HARCOURT STANDARD PENTANE LAMP.—E. B. Rosa, E. C. Crittenden, & A. H. Taylor.—*J. Opt. Soc. Amer.*, 1921, **5**, 444–452.

The decrease in candle-power of the Harcourt 10-candle pentane lamp for every increase of 1 litre of water vapour per cub. m. of air is given by the National Physical Laboratory as 0·645%, whilst the result obtained by the U.S. Bureau of Standards is 0·567%. The discrepancy

is due to a difference of atmospheric temperatures at which the experiments were carried out. It has been found that these experimental values agree if two factors are employed (1) a factor of 0·52% decrease of candle-power per litre increase of water vapour per cub. m. of air, and (2) a factor of 0·08% decrease per degree rise in temperature.

These factors also agree with the results obtained by Takatsu and Tanaka in Japan. 15° C. is suggested as a suitable normal atmospheric temperature for calculating the candle-power of the lamp.

CALORIMETER COMBUSTION BOMB.—W. A. Roth, R. Macheleidt, and I. Wilms. *Z. Angew. Chem.*, 1921, **34**, 537–8.

In place of the usual bomb with enamelled or platinised interior Krupp's special acid-resisting "V_2A" steel is employed which has an approximate composition of 20–23% Cr., 6–9% Ni., and 0·1–0·3% C. A quartz or porcelain dish, for the substance to be burnt, hangs by two hooks from the electric leads, one of which is composed of a "V_2A" steel rod, whilst the other is a silver tube which serves also for admission of oxygen and as an exit for the products of combustion. It has not yet been found possible to produce a small steel tube. The bomb can be used for ordinary organic compounds and those containing nitrogen, but not where halogens or large amounts of sulphur are present.

With the former class only 0·2 mg. of iron and no nickel goes into solution, whilst with the latter several mgs. of both are dissolved from the bomb. With use, however, this susceptibility to attack decreases and sulphur compounds can be successfully combusted.

COLORADO SHALE OILS.—A. J. Franks. *Chem. and Met. Eng.*, 1921, **25**, 731–5, 778–82.

The oil, obtained from shale from the De Beque region, was distilled in the ordinary way up to 300° C., and above that temperature with a current of hydrogen passing through the boiling liquid. The sp. gr. of the distillates was 0·782–0·975, % saturation 52·2–11·6, % S. 0·75–0·52, % N. 0·599–2·084. The light oils below 270° C. were stable under repeated distillation, but the heavy oils decomposed at once with formation of new saturated compounds. These unstable heavy oils are unsaturated bitumens containing sulphur, nitrogen, and oxygen, but practically no unsaturated hydrocarbons, and are probably intermediate products of the distillation of oil shale. It is thought that the production of oil by distillation of the organic material in shale is due to depolymerisation and successive breaking down of unsaturated complex bodies to simpler and more stable compounds.

SODIUM DERIVATIVES OF TRUE ACETYLENE HYDROCARBONS.—Picon. *Comptes rend.*, **173**, 155–8.

Sodamide in liquid ammonia reacts with true acetylenic hydrocarbons to give quantitative yields of the sodium derivative. Boiling benzene may be substituted for liquid ammonia with the higher members above isoheptinene. Sodium acetylide heated at 180°–210° C. in a vacuum gives pure sodium carbide, and the latter heated at 290° C. decomposes into sodium and carbon.

THE EFFICIENCY OF FRACTIONATING COLUMNS IN VACUUM DISTILLATIONS.—L. Smith. *J. pr. Chem.*, **102**, 295–304.

A mixture of glycerol monochlorhydrins was distilled under vacuum through a variety of different columns. Bulbous columns have in general little efficiency and are markedly inferior to the rod and disc and Vigreux types on account of incomplete mixing of the vapours. Rate of distillation has a great effect on the separation, an efficient Vigreux column and the worst still-head being equal when the rates of distillation are as 2·5 to 1.

DEHYDRATION OF TAR IN THE LABORATORY.—W. J. Huff. *J. Ind. Eng. Chem.*, No. 12, **13**, 1123.

Since water is lighter than tar only the top layers of the mixture should be heated. This is effected by plunging the tar still into a bucket of water almost up to the surface level of the tar and heating the exposed portion by a ring burner. By this means loss by frothing is avoided, and and light oils can be condensed with the water vapour in the usual way.

FACTORS AFFECTING THE STABILITY AND INVERSION OF OIL-WATER EMULSIONS.—L. W. Parsons & O. G. Wilson. *J. Ind. Eng. Chem.*, No. 12, **13**, 1116–23.

The authors describe results obtained in studying the factors that influence the stability and inversion point of (1) emulsions of pure medicinal paraffin (Nujol) and water, (2) the same with the addition of substances present in commercial oils, and (3) a comparison of the properties of the above systems with different commercial oils. No true inversion point was noted when the ratio of the volume of the two phases was the only variable. Opposing emulsifying agents, such as sodium oleate in water and magnesium oleate in oil, gave no sharp inversion point on being mixed. Oil-in-water emulsions of medicinal paraffin were completely inverted by aqueous solutions of the following salts: Mg. SO_4, Mg. Cl_2, Fe. SO_4, $Al_2(SO_4)_3$, Fe. Cl_3. When the equivalent concentration of polyvolent metal exceeds that of monovalent soap complete inversion resulted, but when less only partial inversion occurred, both types of emulsion being present. Variations in the anions of the precipitating salts studied had no effect. Neutral monovalent salts, such as sodium sulphate, chloride, and iodide, had no inverting action on oil-in-water emulsions, but when present in sufficient concentration broke the emulsion by salting out. Variation in the anion had some effect in salting out. Amylene stabilised emulsions of oil-in-water in proportion to its concentration, other substances present in commercial oils having a very weak effect. The emulsifying effect of some crude oils with water and with sodium oleate solution and the concentration of sodium chloride necessary to break them was briefly studied.

DETERMINATION OF MOISTURE IN INSULATING OILS.—G. J. Rodman. *J. Ind. Eng. Chem.*, No. 12, **13**, 1149–50.

A table of previous methods is given. The author obtains an accuracy of $\pm$ 0·001%. The oil to be examined is heated to 140° C. under 1 mm.

pressure in a flask, which is continuously shaken. All water vapour is quickly driven off and frozen, together with some oil vapours, by liquid air. The freezing mixture is then removed and the combined vapours passed through phosphorous pentoxide in a weighing bottle. Water vapours only are trapped at this low pressure.

THE PYROLYSIS OF SOME HYDROCARBONS.—F. Denig. *J. Chem. Met. Eng.*

The decomposition and vapour pressures of hexane, gasoline, kerosene, and vaseline were investigated by heating in a pressure bomb, noting the temperatures and pressures on heating and cooling and analysing the resultant products. Curves and tables are given. Hexane could not be heated high enough to reach its decomposition point of 510° C. Gasoline did not crack at all when heated to 380° C. under 790 lb. per sq. in. It does not follow Boyle's law. Kerosene decomposes at about its boiling-point. Vaseline breaks down almost completely to gasoline and kerosene, which together contained 20% of aromatic and 9% of olefine compounds.

EVAPORATION TEST FOR LIGHT PETROLEUM OILS.—M. Freund & G. Palik. *Petroleum*, 1921, **29**, 1029–33.

A good idea of the technical value of light petroleum oils can be obtained from a knowledge of the sp. gr. and of the evaporation valve. The latter is estimated as follows: 50 cc. of oil at 20° C. are run from a pipette, capable of delivering 50 cc. of distilled water in 5 mins. 35 secs., through a copper tube sloping at an angle of 20° to the horizontal, surrounded by a steam jacket 100 cm. long, into a cooled measuring cylinder. The loss in volume is termed the evaporation value.

PREPARATION OF A PETROL FROM A VEGETABLE OIL.—A. Mailhe. *Compt. rend.*, **173**, 358–9.

Linseed oil is passed over a mixture of electrolytic copper and magnesium oxide as catalyst heated to 550°–650° C., and then hydrogenated over reduced nickel. A mixture of aromatic and cyclic hydrocarbons are obtained, amongst which benzene, toluene, xylene, cyclohexane, and methylcyclohexane were identified.

EMULSIFICATION SYMPOSIUM.—*J. Ind. Eng. Chem.*, No. 11, **13**, 1008–17.

Papers read at the sixty-second meeting of the American Chem. Soc., September 6th, 1921. A general survey of present-day knowledge of the subject.

"Emulsions with finely divided Solids."—T. R. Briggs.

"Emulsifying Agents in Oil-Field Emulsions."—J. L. Sherrick.

"Common Characteristics of Crude Petroleum Emulsions."—F. E. Ayres.

"Oil-Field Practice in handling Crude Oil Emulsions."—S. Born.

"Recovering Petroleum from Emulsions by Chemical Treatment."—R. R. Matthews & P. A. Crosby.

"Electrical Dehydration of Crude Oil."—W. G. & H. C. Eddy.

FILTRATION SYMPOSIUM.—*J. Ind. Eng. Chem.*, No. 11, **13**, 976–1007.

Papers read at the sixty-second meeting of the American Chem. Soc.,

September 6th, 1921. A general survey of present-day knowledge of the subject.

(1) "Washing and Washing Ports in connection with 'Chamber,' and 'Frame' Filter Presses."—E. A. Alliott.

(2) "Filter Cloth and its relation to Filtration."—A. A. Campbell.

(3) "Industrial Filter Media."—A. Wright.

(4) "Fundamental Laws of Filtration with Suggestions regarding Research Work."—D. R. Sperry.

(5) "The Feeding of Filters."—J. F. Springer.

(6) "Filter Aids."—C. P. Derleth.

(7) "The Use of Filter-cel for Industrial Filtration Processes."—G. M. Hickey.

(8) "Centrifugal Filters."—H. C. Beckmann.

(9) "Discussion of Centrifugal Drainage."—T. A. Bryson.

(10) "Pulp and Filter Mass Filters."—E. E. Finch.

(11) "Leaf and Rotary Suction Filters."—G. D. Dickey.

(12) "Plate and Frame Filter Presses."—E. C. Alford.

(13) "Modern Leaf Type Filters."—R. C. Campbell.

(14) "Oliver Continuous Filters."—H. A. Morrison.

(15) "The Atkins-Shriver Automatic Filter Press."—H. D. Atkins.

(16) "Vallez Rotary Filter."—H. A. Vallez.

Some Chemical Considerations of Petroleum Refining.—B. T. Brooks. *Chem. Inst. Eng.*, **24**, 1022–5.

The author emphasizes the necessity of more chemical research on petroleum refining, with publication of results for general information. Problems requiring attention include the chemistry of non-benzenoid hydrocarbons, the refining of unsaturated oils and the measurement of the lubricating value of oils.

The Mines and Refinery of Pechelbronn.—P. & J. de Chambrier. *Mat. grasses*, **13**, 5784–92.

A history of the development of the mines and refinery and a study of the local geology. Methods employed for working the sands for petroleum and a flow sheet for refining the crude oil are given.

Comparison of Methods of Determining Water in Petroleum.—J. Angli. *Anales Soc. Quim. Argentina*, **8**, 105–17.

A comparison based on practical tests with a criticism of each method.

Volatility of Internal-Combustion Engine Gasoline.—F. A. Howard. *Sci. Lubrication*, **1**, No. 2, 14.

A definition of the term "gasoline" is given. Volatility is described as the ability to form a stable 1–2% mixture with air. Complete vaporisation of heavier fuels is declared possible, and the relationship of time, surface and heat to vaporisation is discussed. Data of the physical and chemical properties of internal-combustion engine fuel are given.

RECLAIMING SLUDGE ACID IN PETROLEUM REFINING.—W. H. Simonsen & O. Manitus. U.S. Pat. 1,384,778.

The sludge acid is concentrated at a temperature so low that the organic matter is not charred. Such a condition is achieved by the use of a partial vacuum.

APPARATUS FOR HEATING OIL IN TANKS ON SHIPS.—W. J. McLay & G. J. Carter. E.P. 170,894.

An improved method of insulating steam pipes in an oil-tight manner, so that they may be carried through oil tanks intervening between the boiler and the tank to be heated. The pipes are surrounded by insulating material enclosed in a metallic casing, which is joined in an oil-tight manner to flanges near the ends of each pipe, the space between adjacent flanges on consecutive pipes being also filled with insulating material surrounded by a movable oil-tight metallic casing.

HEAT EXCHANGERS FOR USE WITH FLUIDS.—*Société Franco-Belge de Fours à Coke.* E.P. 159,489.

The device consists of a rectangular chamber divided internally into many narrow vertical chambers by iron walls. One series of alternate chambers is connected in pairs at the top only by external pipes and contains the heated fluid, whilst the other series of alternate chambers carrying the heating fluid is connected in pairs alternately at their upper and lower parts.

LUBRICANTS.—W. Crawford. E.P. 170,705.

A lubricant for use with shafting and gear-wheels is made by melting together beef-tallow and beeswax at 150° F. and saponifying the mixture with caustic potash. Colouring matter and perfumes may be added before the soap sets.

PRODUCTION OF POWER-ALCOHOL IN THE BRITISH EMPIRE.—Second memorandum of the Fuel Research Board.

Data are given of the consumption of motor fuel in different parts of the Empire and the capacity of each to grow sufficient vegetable material for the purpose of producing power alcohol. The conclusions arrived at are that the manufacture of alcohol from home-grown materials is only likely to be commercially possible in the near future in some of the Dominions and Colonies, and then only on a sufficient scale to meet local requirements. Synthetic production of alcohol from either calcium carbide or ethylene on a commercial scale in the British Isles is considered as extremely unlikely at the present time.

BENZOL FOR TRANSPORT PURPOSES.—E. de Normanville. *Gas Journal*, 1921.

The author considers that all benzol used for internal combustion engines should conform to the specifications of the National Benzol Association if trouble is to be avoided. The practical advantages of benzol over petrol are: (1) more power, (2) increased mileage, (3) no pinking, (4) economy of use, (5) sweeter running, (6) home production, whilst the disadvantages comprise: (*a*) higher freezing-point, (*b*) lower volatility, (*c*) stronger solvent for paints; (*a*) can be avoided by adding toluol, (*b*) is declared of no consequence practically, and (*c*) merely requires care in filling tanks. The present increased cost is more than

outweighed by diminished running costs per mile, but stress is laid on the importance of using the right kind of lubricating oil, which must be high-grade mineral base oil and not animal or vegetable compound oils. The author also discusses the present position as regards production, and expresses the opinion that cheaper gas oil as a substitute for benzol, stripped from illuminating gas, is the only means of enabling gasworks to profitably produce more benzol for transport purposes.

Commercial Benzines.—A. Ganswindt. *Neuste Erfin. u. Erfahr.*, **37**, 74–9.

A brief review of the different grades of benzine, their origin and methods of preparation, including the catalytic reaction of hydrogen on carbon monoxide or dioxide in the presence of cobalt oxide or osmic acid.

Removal of Fluorescence from Vaseline Oils.—G. Meyerheim. *Deut. Parfümerie Ztg.*, **6**, 123–5.

Fluorescence and odour must be removed from oils intermediate between kerosene and lubricating oils before use in perfumery. The latter is removed by repeated steam distillation, rejecting the head fraction each time. Hydrocarbons, such as pyrene and chrysene, are responsible for fluorescence, which may be removed by (1) treatment with sulphuric acid and alkali followed by distillation with steam, or (2) by adding yellow compounds, such as nitrated or brominated and nitrated naphthalenes, or quinoline yellow, or (3) by treatment with oxygen in the presence of ultra-violet light.

Distilling Oils.—J. G. P. Evans. E.P. 162,873.

A conical still is heated at its upper end only by an electric heater or other means and oil vapours are condensed in the space between the still and an outer insulated jacket. Different factions are collected in a series of channels having drip flanges above them. Crude oil is continuously supplied to the base of the still and residue withdrawn by a pipe having a small opening at the top to prevent syphoning. A temperature of 560° F. is maintained at the top of the still.

Hydrogenated Compounds as Fuels for Internal-Combustion Engines. —*Schranth. Brennstoff. Chem.*, **2**, 184.

Mixtures of tetralin with petrol or benzol can be used satisfactorily with ordinary motors, whilst tetralin itself is suitable for the modern high-compression engine. The higher cyclohexanols produced by hydrogenation of tar phenols can be dehydrated to cyclohexenes, which with cyclohexane and dekalin afford other possibilities as motor fuels.

A Comparative Study of Fractionating Still-heads.—N. P. Moore. *J. Phys. Chem.*, **25**, 273–303.

The object of the investigation was to determine the factors which must be controlled in order to obtain the best separation of the components of a mixture by a single distillation. A refractometer method, which avoids the necessity of temperature control, is described, as well as an apparatus for studying the relative efficiencies of a cylindrical still-head under varying conditions when fractionating a mixture of 75% chloroform and 25% carbon tetrachloride. Factors of importance are deduced from the results. A new type of still-head which is flat with

numerous slotted angle strips on the bottom was designed in order to study the influence of these factors and is described in detail. With this apparatus the efficiency value was raised to 82·7% compared with 47·8% of the best cylindrical still-head.

DISTILLATION OF MINERAL OILS.—L. Granger & C. Mariller. E.P. 154,558.

An apparatus for utilising the heat contained in the distilled vapours to raise steam which can be employed for other useful work. The device consists of a form of tubular boiler in which the oil vapours surround the tubes carrying water. The apparatus is said to work efficiently when the temperature of the oil vapours is no more than a few degrees above that at which water boils.

PRODUCTION OF A MOTOR SPIRIT.—A. G. Burnell & R. W. Dawe. E.P. 171,566.

Oil gas is subjected to a pressure of 150 lb. per sq. in. and the condensed liquid treated with an anhydrous metallic chloride, such as aluminium chloride, while heating under a reflux condenser. After fractional distillation the distillate is washed with soda and water. Gummy residues are thus eliminated.

IMPROVEMENTS IN HYDRAULIC STORAGE OF OIL.—E. Y. Dow & N. E. McClelland. E.P. 171,575.

Oil in the storage tank is discharged by water pressure, the object of the invention being the reduction of the number of valves generally in use in such systems.

IMPROVED PROCESS OF DISTILLING OILS.—A. Irini. E.P. 146,183.

Two stills are connected by pipes between their vapour spaces as well as between their liquid spaces. One still only is heated, the vapours from which pass continuously into the liquid in the other still and thus raise the temperature of the charge till distillation commences. Liquid flows continuously from the distillation still to the heated still to preserve the level of liquids in the two.

PROCESS AND APPARATUS FOR DISTILLING PETROLEUM UNDER PRESSURE.—H. P. Chamberlain. E.P. 164,358.

An extension of E.P. 146,472, whereby superheating of the evolved vapours is avoided by making them traverse a space removed from heating agencies, condensing the vapours under pressure and returning high-boiling liquids to the still.

SCIENCE'S FUTURE WITH OIL.—A. D. Little & R. E. Wilson. *Petroleum Age*, 1921, No. 14, 16–18, and No. 15, 86 and 99.

A non-technical recapitulation of the chemistry of petroleum and the possible chemical and physical reactions whereby other compounds, such as aldehydes, organic acids, ethers, etc., can be produced from the components of petroleum oils. The authors discuss the fact that so far petroleum is not an essential raw material for any chemical industry worthy of the name, and give as reasons the present lack of chemical knowledge regarding the higher members of all series of hydrocarbons and the impossibility of isolating the same on the large scale. They plead for publication of all research on petroleum as being the only way in which real progress can be made.

METHODS OF TESTING PETROLEUM PRODUCTS.—*National Petroleum News*, 1921, No. **46**, 51; No. **47**, 63; No. **48**, 41.

Tentative methods put forward by the American Society for Testing Materials for criticism and discussion.

The original papers should be referred to for details.

No. **47**, 63. VISCOSITY OF FUEL AND OTHER HEAVY OILS.—The Saybolt Furol Viscometer shall be used for oils having a viscosity above 25 secs. at 122° F. and the Saybolt Universal viscometer for those below this figure.

DETECTION OF FREE SULPHUR AND CORROSIVE SULPHUR COMPOUNDS.—A strip of clean copper foil is half submerged in the oil and left overnight at a temperature of 150° F. Any discoloration is indicative of the presence of harmful sulphur compounds.

QUANTITATIVE ESTIMATION OF SULPHUR IN NAPHTHA AND KEROSENE.—A lamp of the Esling type is advocated. The oil is not mixed with any solvent and the amount burnt is obtained by weighing the lamp before and after use. Sodium carbonate solution is employed to absorb the products of combustion, and hydrochloric acid, with methyl orange as indicator, is used for estimating the excess of carbonate remaining. A formula is given for working out the percentage of sulphur present when using standard solution.

No. **48**, 41. PRECIPITATION NUMBER OF LUBRICATING OILS.—The precipitation number is defined as the number of cub. cm. of precipitate formed when 10 cc. of lubricating oil are mixed with 90 cc. of petroleum naphtha of definite quality and centrifuged under definite prescribed conditions. A description of the apparatus and conditions for carrying out the test are given. An accuracy of 0·1 should be obtained.

FLASH- AND FIRE-POINTS WITH THE OPEN CUP.—The Cleveland open cup shall be used for all oils except fuel oils and those having an open cup flash-point below 175° F. A detailed description of the apparatus and methods of carrying out the test are given.

DETERMINATION OF OIL AND WATER IN PARAFFIN WAX.—C. K. Francis & H. T. Bennett. *National Petroleum News*, 1921, No. **48**, 31.

Any foreign matter is first removed from the surface of the wax and a mixed sample of the exterior and interior of the cake then taken, pulverised and quartered to get a fair sample. A lever press of 5½ in. diameter and capable of a pressure of 1000 lb. per sq. in. is employed. Two linen cloths and two hard filter papers, of the same size as the press, are weighed, and 10 to 15 gms. of wax laid between the cloths and filter papers. The sandwich is then placed in the press, the whole apparatus cooled to 60° F., and a pressure of 1000 lb. per sq. in. applied for five minutes. The wax is next removed and the cloths and filter papers weighed, the increase in weight is taken as the amount of water and oil present. Modifications of the method are (1) weigh wax and linens before and after pressing to find loss; (2) use larger samples, up to 500 gms.; (3) silesia substituted for linen and filter paper; (4) press for ten minutes; (5) a correction is made for wax retained on the linens; (6) maintain room at 60° F. instead of only cooling press to 60° F. The

chief objections to the method are that (1) it is impossible to avoid wax remaining on the linens; (2) a corrective factor will not apply to different waxes; and (3) a constant temperature is only possible in a specially constructed room. By using different methods results vary by 0·5 to 2·5 per cent, but by the method first given an accuracy of 0·1 to 0·3 per cent can be obtained. The results, however, are comparative and not absolute, and a method is still to be devised which will give the true oil and water content.

IMPORTANCE OF THE OLEFINE GASES AND THEIR DERIVATIVES.—G. O. Curme, H. O. Curme, and C. O. Young. *Chem. Met. Eng.*, 1921, 907, 957, 999, 1091.

A series of papers written with the object of demonstrating in a general way the technical importance of the olefine gases.

1. *Sources and uses of Ethylene and Propylene.*

Pure ethylene was first described in 1795 by four Dutch chemists, Diemann, Troostwyk, Boudt, and Louwrenburgh, who also prepared pure ethylene dichloride. In 1826 Hennell produced ethyl hydrogen sulphate from ethylene and sulphuric acid and established its relationship to ethyl alcohol, and in 1862 Cotelle tried to manufacture ethyl alcohol on the large scale by absorbing ethylene from illuminating gas in sulphuric acid and subsequent hydrolysis. Shortly after this Berthelot proved that propylene produced isopropyl alcohol by the same reaction, but large scale work was also a failure. In 1900 Fritschke started in the United States to manufacture ether from ethylene produced by cracking petroleum and continued operations until 1907. Potato spirit was employed in Germany for producing ethane from ethylene by hydrogenation for use as a refrigerant, and in the same country ethylene chlorhydrin was manufactured from ethylene and bleaching powder for use in the synthesis of indigo. During the war this was extended to the production of mustard gas and nitro ethylene glycol, which was employed as a propellant. Ethyl alcohol has also been produced from ethylene made by the partial hydrogenation of acetylene, but not commercially. From 1912–18 ethylene and propylene chlorhydrins were manufactured with indifferent success from the vapours of cracked petroleum by the Commercial Research Co. in the United States, but towards the end of the war 200 tons per day of mustard gas was being produced by the ethylene-sulphur monochloride process from ethylene from alcohol. Isopropyl alcohol from propylene of cracked petroleum vapours is now being made largely in America, whilst the Skinningrove Iron Works in England are absorbing ethylene from coke-oven gases on an industrial scale.

Olefine gases in a pure state are still only to be obtained from their respective alcohols on the large scale by passing the alcohol over a catalyst, such as kaolin, heated to 350°–600° C. with or without steam. The pyrolysis of organic matter, such as the cracking of oils and production of gas from coals, etc., is the largest source at present of mixtures of olefine gases, the concentration of ethylene and propylene in cracked oil gas having been found as high as 35–45 per cent, but is usually under 10 per cent. Coke-oven gas contains from 2 to 4 per cent. Extraction

of the desired constituent is generally done by absorption in a solvent such as sulphuric acid or by combination with a reagent such as chlorine to produce a condensable product. The author has patents pending for a new process of production. A table of the physical properties of ethylene and propylene is given. The industrial uses to which these gases may be put are welding, illuminating, and refrigerating, and as raw material for organic preparations their chemical activity makes them extremely valuable. The following are a few products: denatured alcohol, isopropyl alcohol, ethyl ether, ethylene chlorhydrin, ethylene glycol, ethylene dichloride, mustard gas, diethyl sulphate, ethylene oxide, oxalic acid, formaldehyde, formic acid, acetone, propylene glycol and propylene chlorhydrin.

2. *Diethyl Sulphate.*

Dimethyl sulphate has been commercially available and largely used for methylation for some time, and it is expected that the diethyl homologue will rapidly progress now that it can be made in even larger quantities. Wetherill first obtained it in 1848 by the action of sulphur trioxide on absolute ether. It is a non-inflammable, colourless, neutral liquid with faint ethereal odour. $D^{15}_{4^\circ} = 1{\cdot}1837$. M. Pt. $= -24{\cdot}5^\circ$ C. B Pt. $= 96^\circ$ C. at 15 mm. pressure and $120{\cdot}5^\circ$ C. at 45 mm. At ordinary pressure slight decomposition occurs above 140° C., and at 208° C. it boils with considerable decomposition—the true boiling-point being probably a few degrees higher. It is not miscible with cold water, is slowly hydrolysed by warm, and decomposed by boiling water into two molecules of ethyl alcohol and one of sulphuric acid. As an ethylating agent it is now giving almost theoretical yields in some industrial processes, though at first unsuccessful owing to use of impure material made by the vacuum distillation of ethyl alcohol-sulphur trioxide mixture, dry distillation in vacuo of sodium ethyl sulphate, or by the interaction of chlorsulphonic acid and absolute ether. The author now produces high purity diethyl sulphate directly from pure ethylene, and commercial sulphuric acid by means of a continuous cycle (U.S. Pat. 1,339,947) in commercial quantities. Unlike dimethyl sulphate the diethyl compound is no more dangerous to handle than aniline or benzene, etc. No more than ordinary precautions against inhaling fumes of the located material are necessary. Ethylation by means of this compound is brought about very easily. No autoclave is required, and at most it is only necessary to warm the materials under a reflux condenser. Water should be absent, if possible, and it is desirable to form the sodium salt of the material to be ethylated or work in the presence of an equivalent amount of caustic soda in order to prevent formation of free acid.

As a rule the first ethyl group reacts more readily than the second, and in certain cases it is advisable to use only one and employ the residual ethyl hydrogen sulphate for other purposes. The following have already been produced commercially by means of this reagent. Ethyl chloride, bromide, iodide, nitrite, sulphite, mercaptan, sulphide, cinnimate, laurate, oleate, stearate, etc.; ethylated phenols and amino compounds as well as starch and even cellulose. The advantages as a commercial ethylating agent are (1) rapid ethylation without pressure

vessels; (2) high intensity of reaction, thus economising material; (3) no expensive acid radicle to recover; (4) can be handled without loss owing to low volatility; and (5) is non-toxic, non-inflammable and non-corrosive.

Ethylene dichloride.

First produced in 1795, this substance seems to have been overlooked until lately as an industrial solvent. It is a colourless liquid with chloroform-like odour, boils at 83·5° C. at 760 mm. and melts at −36° C. $D^{\frac{20}{4}}_{4} = 1{\cdot}2569$, specific heat 0·3054 at 30° C. and latent heat of vaporisation 157·5 BTh.U. per lb. at 0° C. The only commercial means of manufacture is the direct combination of ethylene and chlorine under varying conditions which are the subject of patents. (Mercerean, U.S. Pat., 1,224,485; Brooks and Smith, U.S. Pat. 1,231,123 and 1,235,283; Tinker, E.P. 108,062; Harding, E.P. 126,511.) The gases were simply mixed and the condensate drawn off, but the heat of reaction produced higher chlorinated products such as trichlorethane. Cooling the gases and using catalysts has been suggested (Smyth, *J. Soc. Chem. Ind.* **35**, 1,130; Brooks and Humphrey, *J. Eng. Ind. Chem.* **9**, 750). Brooks and Smith (loc. cit.) suggested chlorine dissolved in a solvent for the production of mixed ethylene and propylene dichlorides from oil gas, and sulphuryl chloride for chlorinating unsaturated hydrocarbons from oil gas. The author has found that dry ethylene and liquid chlorine react smoothly and rapidly to form ethylene dichloride (U.S. Pat. 1,315,542 and 1,315,545) when the temperature is kept below 0° C. and the pressure equals the vapour pressure of chlorine. Very little further chlorination occurs. Extreme conditions are necessary to bring about chemical reaction with ethylene dichloride, such as hydrolysis to glycol by alkali at a high temperature. This stability, together with its high solvent action on oils, fats, waxes, etc., make it an excellent solvent. Carbon tetrachloride, acetylene tetrachloride, tri- and dichlorethylene all split off hydrochloric acid in the presence of boiling water, but this does not occur in the ethylene dichloride. Unlike chloroform and carbon tetrachloride, very little oxidation takes place and therefore partly filled containers are no danger. It only burns with difficulty, and being heavier than water any fire can be extinguished by the latter. Although it has been used as an anæsthetic, the vapours are no more dangerous than those of many other organic solvents. The characteristics which recommend ethylene dichloride as a solvent are: (1) excellent solvent for fats, oils, and greases; (2) pure chemical with constant boiling-point; (3) completely removable from both extract and residue, bearing no taste or odour; (4) low sp. gr. and heat of vaporisation; (5) stability permits indefinite re-use; (6) does not corrode metal even in presence of boiling water; (7) no danger to workers and low fire risk.

Ethylene chlorhydrin and Ethylene oxide.

Ethylene chlorhydrin, $CH_2Cl.{}_2CH_2OH$, was first prepared by Wurtz in 1859 by adding hydrochloric acid to ethylene glycol. Later Carius produced it by the addition of hypochlorous acid to ethylene, on which reaction the present commercial process is based. Carius made his hypo-

chlorous acid by the action of mercuric oxide on chlorine water, and later workers added a weak acid such as boric acid, carbonic acid, and sodium bicarbonate to a dilute solution of bleaching powder. In 1910 Walker patented the addition of an excess of sodium bicarbonate to an alkaline solution of sodium hypochlorite in the presence of ethylene (U.S. Pat. 972,952 and 972,954). Later McElroy patented the action of chlorine on ethylene and oil gas in the presence of steam, and in an electrolytic cell (U.S. Pat. 1,253,615, 6 and 7; 1,264,535; 1,295,339; 1,315,229). The Badische Anilin und Soda Fabrik bubbled a mixture of ethylene and carbon dioxide through a suspension of bleaching powder in a lead vessel and by this means made most of the chlorhydrin for the production of mustard gas during the war. Gourberg (*J. Am. Chem. Soc.* **41**, 1414) obtained 5 to 8 per cent concentrations by passing ethylene and chlorine into cooled water, but above that strength ethylene dichloride was formed owing to accumulation of hydrochloric acid. Brooks added salts of weak acids, such as borax or sodium bicarbonate to take up the hydrochloric acid, but obtained no better results. The authors have raised the concentration to 10 to 12 per cent by means of a recirculating system without the addition of salts. Pure ethylene chlorhydrin is a colourless liquid with faint ethereal odour, boiling at 128° C. at 74 mm. and has $D_4^{15} = 1{\cdot}2130$. It is miscible in all proportions with water with which it forms a constant boiling mixture containing 42·3 per cent of chlorhydrin by weight, boiling at 96° C. at 740 mm., $D_4^{15} = 1{\cdot}097$. It is best marketed in this form, since concentration to absolute is expensive though not excessively difficult. Absolute ethylene chlorhydrin is a powerful solvent of all materials from inorganic salts to cellulose esters, but has the disadvantage of being readily hydrolised. It is extremely reactive chemically at both ends of the chain and thus of great importance in synthetic chemistry. Aniline was made by the Badische Anilin und Soda Fabrik by the use of this substance as well as mustard gas during the war. Phenyl ethyl alcohol was made from brombenzene and ethylene dichloride by the Grignard reaction, and novocain by its action on animo benzoic esters.

Ethylene oxide was first made by Wurtz in 1859 by splitting off hydrochloric acid from ethylene chlorhydrin by means of strong caustic alkali. No improvements have yet been made on this method. Ethylene oxide $(CH_2)_2O$ is a colourless liquid with pungent odour, boiling at 12·5° C. at 746mm. $D_4^0 = 0{\cdot}8966$ and mixible in all proportions with water. It is easily transported as a liquid in steel cylinders. It is extremely reactive chemically, and being readily prepared anhydrous and free from chlorine is often preferable to ethylene chlorhydrin in making the same compound.

Ethylene glycol, $CH_2OH.CH_2OH$, is readily prepared by the action of sodium carbonate on chlorhydrin solutions. It can replace glycerine with advantage in many uses. Glycol monacetate, $CH_2OH.CH_2O.CO\,CH_3$, is claiming attention as a solvent and as an aid in dyeing artificial silk. The diacetate deserves notice as a high boiling solvent (boiling-point 186° C.).

DESTRUCTIVE DISTILLATION OF MIXTURES OF OIL AND COAL.—J. D. Davis, P. B. Place, and G. S. Scott. *Chem. and Met. Eng.*, 1921, 1131.

Oil and coal were distilled separately and mixed together at temperatures of 4, 5, 6, 7, and 800° C. and the yields of oil and gas compared as regards quantity and quality. The conditions of distillation were very similar to those prevailing in the carbonation of water gas, rapid and complete destructive distillation being obtained within a narrow range of temperature. The mixtures are more sensitive to temperature than their constituents. They yield a smaller distillation residue and a larger volume of gas, which is of better quality than the combined gases from coal and oil separately. Mixtures, however, give less light oil and more tar, the latter being of poorer quality owing to excessive quantities of pitch.

REFRACTIVE INDEX OF ROUMANIAN PETROLEUMS.—Cr. Predescu. *Bull. Sec. Sci. Acad. Roumaine* **6**, 150–6.

The sp. gr. and refractive indices of two oils and of their 10° fractions between 50° and 310° C. were determined. The crudes had sp. gr. 0·8671 and 0·8750 at 15° C. and were dark, non-paraffin oils. The refractive indices were measured at 15° C. by sodium light, the method of polarised light with Brewsterian incidence being employed with the crudes and residue. Tables of results are given, including the sp. refractive index according to the formulæ of Gladstone and Lorentz and Torenz. The refractive index of the lighter crude is 1·487, the fractions varying from 1·384 to 1·526. After sixteen months keeping in stoppered bottles in a half-dark room the sp. gr. and refractive indices were again determined and found to have increased slightly owing to resinification. The sp. refractive index increased very slightly with increase of boiling-point of the fractions.

SPECIFIC INDUCTIVE CAPACITY OF ROUMANIAN PETROLEUMS.—Cr. Predescu. *Bull. Sec. Sci. Acad. Roumaine* **6**, 156–9.

The dielectric constants (K) of two crude oils from Campina and of certain fractions were determined by the method of Nernst (*Z. Physic Chem.*, 1894). Certain other Roumanian petroleum products were also investigated. The law of Maxwell ($K = n^2$) holds close for all.

METHOD OF DETERMINING THE DENSITY OF PETROLEUM RESIDUUM.—Cr. Predescu. *Bull. Sec. Sci. Acad. Roumaine* **6**, 148–50.

One gm. of the semi-solid material is made to adhere to the wall of a picnometer and the usual method for solid materials then followed.

"LIGHTENED" GASOLINES.—F. Bordas. *Ann. Fals.* **13**, 539–43.

"Lightened" gasolines are mixtures of straight-run and casinghead gasolines. By dissolving non-condensable gases in relatively heavy oils the sp. gr. of the latter is lowered and their presence marked, but proper carburation made more difficult. It also increases explosion and fire hazards. To determine the amount of dissolved gases (which may reach 10 per cent and more) about 200 cc. are kept near the boiling-point of the sample for 30–45 min. in a flask attached to a condenser dipping into 50 cc. of petroleum cooled by a freezing mixture. The increase in

volume at room temperature gives the volume of the dissolved gases in the gasoline. Increase in sp. gr. due to elimination of the gases is usually of the order 0·010.

NEW METHODS OF UTILISATION OF MINERAL OILS AND COAL.—F. Bergins. *Z. Angew. Chem.* **34**, Aufsatzteil, 341–7.

The application of new products to industry from oil and coal is explained. At the present time there are three problems of vital importance: (1) a new source of supply of petrol; (2) the utilisation of heavy asphaltic oils, probably by conversion to light oils; and (3) the conversion of coal into large supplies of oil. At present the best solution of (1) is the cracking process and (2) has been solved by hydrogenation. A detailed description is given of both processes. Owing to the war (3) is still in an experimental condition (cf. G.P. 301,231).

OIL REFINING IN RUSSIA. *Petroleum World* **18**, 269–79.

Most Russian oils produce petrol and kerosene, but those producing lubricating oils are comparatively not abundant and even less plentiful are those from which vaseline and paraffin wax may be obtained. Paraffinic oils from the new Grosny field are increasing. Refining is done by distillation and the usual treatment with sulphuric acid and alkali. Cracking is avoided. A battery consists of 10 to 15 stills of 20 to 25 tons capacity. The final temperature in the last still is about 270–280° C. The petrol fraction has sp. gr. 0·770 to 0·798 and the kerosene sp. gr. 0·799 to 0·832 and flash-point 28° C. The residue (ostatki or mazout) sp. gr. 0·905 to 0·910, flash-point above 80° C., is distilled in vacuo to obtain various lubricating oils, the residue from this distillation (termed "goudron") being mixed with the residue from the kerosene manufacture and employed as fuel oil. To obtain aromatic hydrocarbons the crude oil is treated in an apparatus similar to that used in making gas from coal. The hydrocarbons are condensed and the gas employed as fuel.

SWEATING PARAFFIN WAX.—A. Szekely. *Seifensieder Ztg.* **48**, 408–9.

The usual dry and wet methods are described and a combination of the two, patented by the author, in which a pan, having a sieve bottom and the upper portion of its sides perforated, carries a set of vertical tubes perforated in their upper portion. The bottom is covered with cold water, on to which melted wax is run and allowed to partially solidify. Warm water then replaces the cold and raises the wax to the perforated portions of the sides through which the "sweats" run off.

CHLORINATING HYDROCARBONS.—F. Sparre and W. E. Masland. U.S. Pat. 1,379,367.

Chlorination of saturated hydrocarbons is effected without danger of explosion by absorbing chlorine in the hydrocarbon in the dark and then exposing the liquid to the action of actinic rays without permitting overlying gas spaces.

ACTION OF MICRO-ORGANISMS ON CRUDE PETROLEUM.—J. Tausz. *Petroleum* **14**, 553–5.

By allowing a layer of petroleum, 1–2 mm. deep, to stand several

weeks over ditch water containing a nutrient, the liquid became turbid with apparent formation of asphalt. No action occurred with thicker layers of oil, but thin slices of paraffin wax were attached. By means of pure culture of micro-organisms it was found possible to effect separation of paraffin and napthene hydrocarbons in refined and crude Russian and American lubricating oils and cylinder stock.

PIPE-LINE TRANSPORTATION OF HOT OIL.—L. L. Barrett. *Chem. Met. Eng.* **24**, 1148–52.

Heat losses from an uninsulated line are four to five times greater than when covered with one inch of 85 per cent magnesia. Spacing of pumping stations is discussed. An insulated line shows a thermal efficiency of 23 per cent over a bare ditched line and requires a pumping station every 16·5 miles compared with 13·7 for the bare line. Figures are given showing the monetary advantage of lagging a pipe line.

TECHNICAL HYDROGENATION OF HYDROCARBONS, NITROBENZENE, ALKALOIDS, AND COAL. *J. Soc. Chem. Ind.*, 1921, **23**, 445R.

A description of the technical methods employed in hydrogenating benzene to cyclohexane, naphthalene to tetra- and decahydro-derivatives, unsaturated aliphatic hydrocarbons occurring in cracked low-boiling petroleum spirit, the production of hydro-alkaloids, anilin from nitrobenzene and the liquifaction of coal. Sabatier's laboratory experiments proved that 70°–180° C. was the optimum temperature for hydrogenating benzene, and that methane and carbon were formed at 300° C., but in practice 300° C. and 300 lb. pressure are employed, benzene and hydrogen being passed through an electrically heated cylinder containing a nickel oxide, platinum or palladium cartridge of catalyst. Before hydrogenating commercial napthalene this compound must be removed. This is effected by stirring molten naphthalene at 180° C. with fuller's earth, kieselguhr, etc., together with an easily fusible metal (sodium or potassium) or with finely divided nickel, etc. Naphthalene in the vapour state or solution may also be similarly treated. After distillation it is treated with hydrogen at 180°–200° C. under 225 lb. pressure in the presence of a nickel catalyst. Sulphur impurities in cracked spirit at present prevent the use of Sabatier's method owing to poisoning of the catalyst, but may in the future be overcome as in the case of naphthalene. Lignite distilled with sodium formate under pressure has given 48 per cent of tar in place of 7 per cent alone. Coal heated with carbon monoxide or hydrogen under high pressures is said to have given large yields of oils, but not so large as that produced by sodium formate.

HYDROGENATION OF ACETYLENE TO FUEL OILS.—K. Oda. *J. Chem. Ind.*, Japan, 1921, **24**, 1161–6.

A mixture of 20 gm. nickel nitrate and 2 gm. mercuric nitrate are oxidised by heating at 250°–300° C. and then reduced in a current of hydrogen at 300° C. This catalyst is active at a lower temperature than nickel alone. A mixture of equal volumes of hydrogen and acetylene are passed over the catalyst at 25°–35° C. at a rate of 3–4 litres per hour. A yield of 51·7 per cent of light oil (olefines) and heavy oil, b.p. 200°–300° C. was obtained.

OIL DISTILLING APPARATUS.—J. S. Smith. E.P. 165,178.

A horizontal cylindrical vessel is provided with trays along which oil flows in a zigzag path to the bottom. Steam is admitted to bring about distillation, and no eternal heat is applied.

PROCESS FOR MAKING CHLORHYDRINS.—B. T. Brooks. U.S. Pat. 1,394,664.

A suitable mixture of chlorine and petroleum still gases are passed into an emulsion of a solvent immixible with water and an aqueous saline extraction medium. Hydrogen chloride and chlorhydrins are formed and the latter recovered.

ETHYLENE CHLORIDE FROM DISTILLATION GASES.—F. Bergius. E.P. 147,909.

The gases produced by distilling coal, lignite, peat, oil, or other carbonaceous matter are purified from ammonia, tar, sulphur, etc., and after being cooled below 120° C. are brought into contact with the theoretical quantity of chlorine in presence of a catalyst such as the chlorides of iron, copper, or antimony. Unsaturated hydrocarbons, chiefly ethylene, are chlorinated and separated by refrigeration, compression, or other means.

DISTILLATION OF TAR, OILS, ETC.—A. M. Duckham and J. S. Morgan. E.P. 170,617.

The liquid is distilled by being forced beneath the surface of molten metal through a hood provided with an annular opening, the sides of which are notched in order to prevent local freezing of the metal and to ensure even distribution of the liquid.

TEST FOR FLASH-POINT.—*Nat. Petroleum News*, 1921, **40**, 57.

A detailed description of the Pensky-Martens apparatus and the procedure to be adopted in making this test as well as those following as advocated by the American Society for Testing Materials.

TEST FOR SAPONIFICATION NUMBER AND TEST FOR WATER IN PETROLEUM PRODUCTS.—*Nat. Petroleum News*, 1921, **50**, 73.

Saponification is brought about by boiling with alcoholic potash. Water is tested for by diluting the sample with petrol, boiling under a reflux condenser and collecting the water in a trap.

TEST FOR WATER AND SEDIMENT BY CENTRIFUGE, AND TEST FOR CLOUD AND POUR POINTS OF PETROLEUM PRODUCTS.—*Nat. Petroleum News*, 1921, **51**, 71.

The sample is diluted with 90 per cent benzol and whizzed under specified conditions. Cloud-point is defined as that temperature at which paraffin wax or other solid substances begin to crystallise out or separate from solution when the oil is chilled under certain definite conditions. The pour-point is the lowest temperature at which the oil will pour or flow, when chilled without disturbance, under definite conditions.

Detailed descriptions of the tests are given.

LUBRICATION AND LUBRICANTS.—L. Archbutt. *J. Soc. Chem. Ind.*, 1921, **24**, 287–293T.

The author reviews the theory of viscous lubrication and the design of bearings, and then discusses the measurement of viscosity by the most well-known instruments, none of which, however, give results having any absolute significance. The absolute C.G.S. unit of viscosity

—the "poise"—is described and its general adoption advocated. The effect of pressure on the viscosity of oils has been proved at the National Physical Laboratory to be much greater with mineral than with vegetable oils, at 6·5 tons to the sq. in., Mobiloil, B.B., increasing in viscosity in ratio of 27 to 1, whilst castor oil only increased 4·5 to 1. This difference had no connexion with change of density, since all the oils were found to be equally compressible. A table is given of the efficiencies of mineral and vegetable oils when tested on the Lanchester worm gear machine, when it was found that at certain temperatures mineral oils exhibited a sharp falling off, whilst vegetable and animal oils maintained their efficiency with only a slight decrease up to 100° C. Addition of vegetable to mineral oil minimised to a certain degree this sharp fall, but did not entirely prevent it. Results show that there is no connexion between the efficiency and viscosity of an oil, the reduction of friction being due to "oiliness," a property possessed in greater degree by animal and vegetable than by mineral oils. None of the usual oil-testing machines are capable of measuring "oiliness," but Mr. Deely has designed a machine which it is considered will become indispensable in an oil-testing laboratory. Its design depends on the fact that when two lubricated surfaces are at rest and in close contact the static friction or face required to cause movement depends on the relative slipperiness of the surfaces. Results obtained with this machine range the oils in general in the order in which practical experience would place them, and shows that static friction bears no relation to viscosity. Changes in the material of the bearing surfaces also shows its effect very clearly, and Mr. Deely concludes oiliness is an effect produced by the lubricant upon the metallic surfaces, the unsaturated molecules of the lubricant entering into a firm physico-chemical union with the latter and forming a compound of oil and metal. In lubrication there are therefore two conditions: (1) where solid surfaces are completely separated by a film of oil, and (2) where no such oil film can form and the solid surfaces rub against one another. In (1) friction depends on the viscosity of the lubricant, and in (2) the efficiency of the lubricant depends on "oiliness" and not viscosity. It has been proved that oil films, so thin as to be of practically one molecule thickness, do act as efficient lubricants and, according to Langmuir, oils containing unsaturated compounds possess an "active group" which cause the molecules to become oriented and pack into the surface layer of a solid. Dunstan and Thole laid stress on the importance in lubricants of unsaturated compounds, which are known to have high viscosities, and thus the value of a mineral oil as a lubricant may depend entirely on its unsaturated constituents. The addition of fatty acids to mineral oils increases the amount of "active groups" and thus improves their oiliness, as has been proved by actual tests with the Lanchester gear, as well as with both the Thurston and Deely machines. Very small amounts of acid are necessary, larger amounts producing no further effect. Colloidal graphite in water and oil suspensions—Aquadag and Oildag—have been added to oils, and to some a slight increase of efficiency was observed. A description is given of the trial of Aquadag as a lubricant in the cylinder of a steam engine, which proved quite successful.